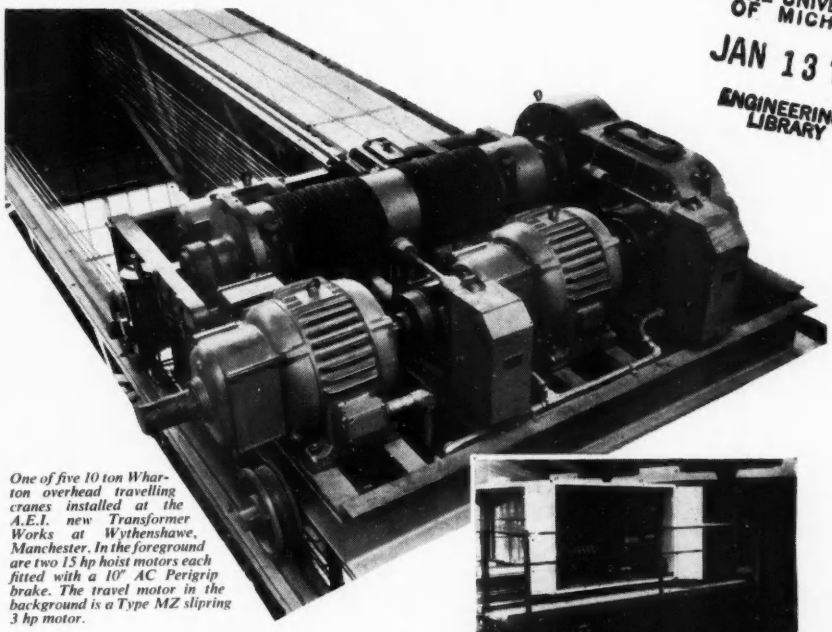
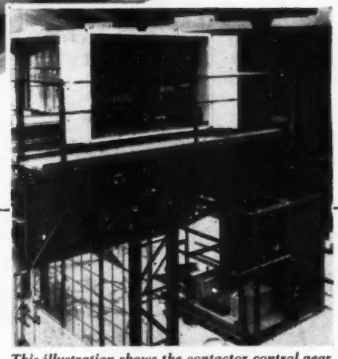
The
ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XX No. 12 DECEMBER, 1959

Complete Hoist Control without Mechanical Braking

THE UNIVERSITY OF MICHIGAN
JAN 13 1960
ENGINEERING LIBRARY



One of five 10 ton Wharton overhead travelling cranes installed at the A.E.I. new Transformer Works at Wythenshawe, Manchester. In the foreground are two 15 hp hoist motors each fitted with a 10" AC Perigrip brake. The travel motor in the background is a Type MZ slipring 3 hp motor.



This illustration shows the contactor control gear and the operator's cabin.

This new system of AC Crane Hoist Control employs two identical slipring induction motors, permanently geared to the hoist motion and running at the same speed. These motors running in conjunction give:—

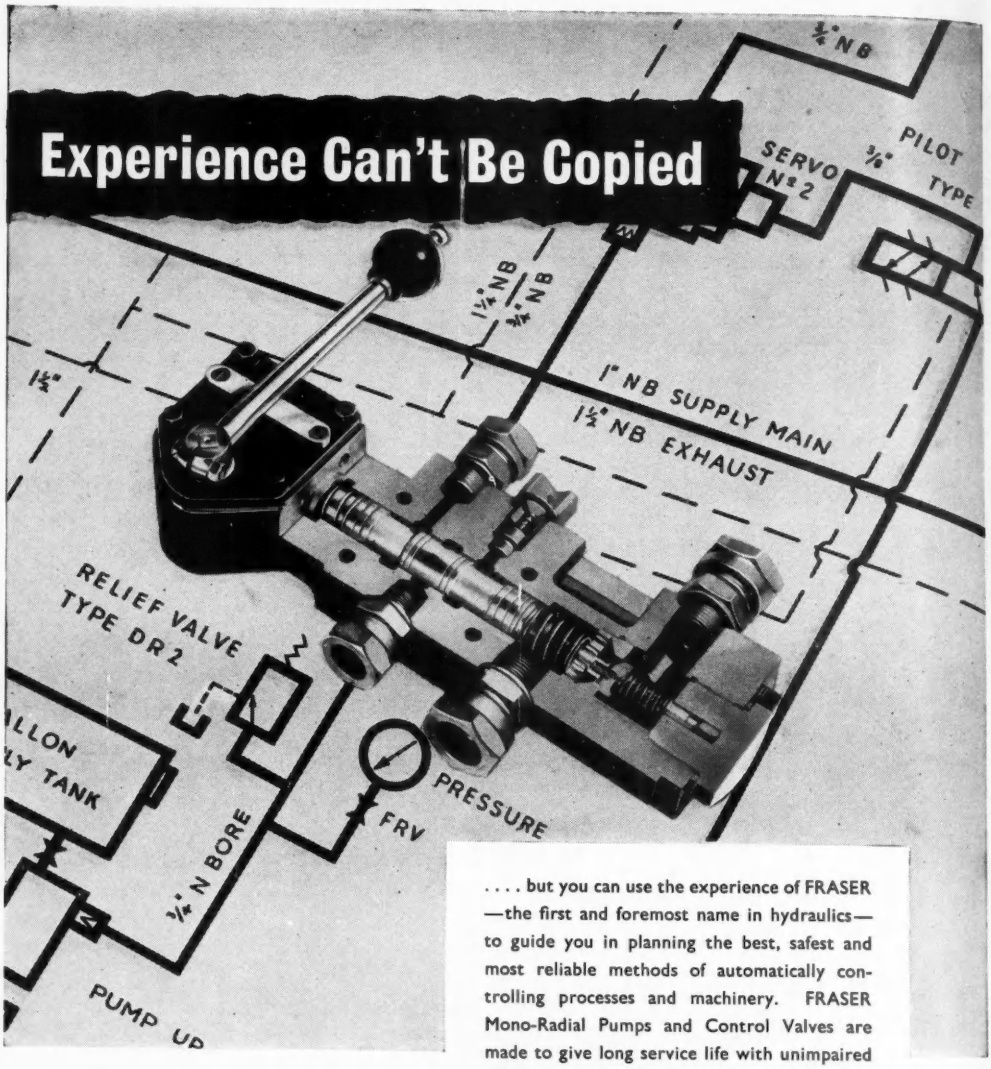
- ✱ Creep speeds hoist and lower, varying little with load.
- ✱ Slow light hook speeds.
- ✱ Electric braking when lowering.
- ✱ Lively hook on lowering notches.

For further information please send for illustrated leaflets.

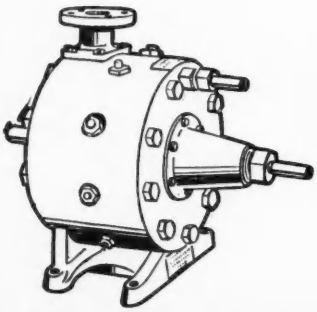
ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

MOTOR & CONTROL GEAR DIVISION RUGBY & MANCHESTER, ENGLAND

INCORPORATING THE MOTOR & CONTROL GEAR INTERESTS OF BTH & M-V



. . . . but you can use the experience of FRASER —the first and foremost name in hydraulics— to guide you in planning the best, safest and most reliable methods of automatically controlling processes and machinery. FRASER Mono-Radial Pumps and Control Valves are made to give long service life with unimpaired efficiency and minimum maintenance costs. ***They are built to last longer—much longer.***



FRASER

FIRST AND FOREMOST IN HYDRAULICS

ANDREW FRASER & CO LTD
29 BUCKINGHAM GATE LONDON SW1

TEL: VICTORIA 6736-9 GRAMS: MONORAD SOWEST LONDON

P.2272

CONTENTS

	Page
The Minidigest	A2
The Blue Pages	473
Universal Joints (Survey No. 6)	477
Moving with the Times	493
"The Singular Affair of the Ministry's Kettle"	494
Methods of Measuring the Speed, Acceleration, and Torque of Moving Parts	496
The Machining of Reactor Materials	497
Adhesive Bonding of Rare Metals	502
Economic Production of High-Precision Steel Balls	503
The Principles and Properties of the Tunnel Diode	505
Investigations into the Effectiveness of Compensating Thermo-Electric Currents for Reducing Cutting-Tool Wear	507
Automatic Machining Line for Spur Gears	509
Christmas Competitions	511
Cryptic Crossword	512
British Industrial Developments	513
Additional Abstracts	516
New Materials, Processes, and Equipment	518
News of the Month	522
New Technical Books	526
Latest Industrial Literature	A95

The ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XX NO. 12 DECEMBER, 1959

EDITORIAL AND ADVERTISING OFFICES:

GREAT BRITAIN
120 Wigmore Street, London, W.1.
Telephone: WELbeck 9357 & 6263

U.S.A.
366 Madison Avenue, New York 17, N.Y.
Telephone: MUrray Hill 2-8865

FRANCE
102 Rue Amelot, Paris (XI^e)
Telephone: VOL. 29-19

ITALY
Via degli Orombelli, 13, Milan
Telephone: 23.16.72

Annual Subscription Rates:
£2 2s. 0d. in the Sterling area, $7.50 in the Dollar area

Printed in Gt. Britain by THE ALCUIN PRESS, Welwyn Garden City, Hertfordshire, and published monthly by the proprietors, ENGINEERS' DIGEST LTD., 120 Wigmore Street, London, W.1.

PITMAN *TECHNICAL BOOKS*

PRINCIPLES OF ELECTRONIC INSTRUMENTS AND INSTRUMENTATION
By Gordon R. Partridge, Ph.D. This new book is an essential aid to the many technologists and research workers who are nowadays faced with instrumentation problems. Based on a series of American postgraduate lectures, it covers the fundamental principles and technique in an outstandingly clear and easy-to-read manner. 40/– net.

FUNCTIONS OF COMPLEX VARIABLES
By Philip Franklin. This book is outstanding for its clear and precise explanation of a branch of mathematics which has often been obscured in a haze of highly abstract concepts. Logical and essentially complete, its purpose is to introduce the reader to the general properties of an analytical function of a single complex variable. 25/– net.

STRENGTH OF MATERIALS FOR ENGINEERS
By D. R. Axelrad, Dipl. Ing., A.M.I.Mech.E., etc. This new book meets the requirements of students preparing for Engineering Degree examinations and those of the professional bodies. Of value also to practising engineers, the book includes a large number of worked examples and additional problems taken from examination papers. 55/– net.

To be published soon

ENCYCLOPEDIC DICTIONARY OF ELECTRONICS AND NUCLEAR ENGINEERING
By Robert I. Sarbacher, ScD., etc. A giant new alphabetical reference work containing all the modern terms and definitions, equipments, elements, components and systems. Over 1,400 pages and a million words, form an inexhaustible compilation of the latest scientific information. £8 net.

FROM ALL BOOKSELLERS

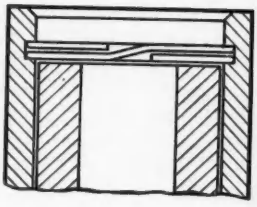
Parker St., Kingsway, London, WC2

SPIROLOX

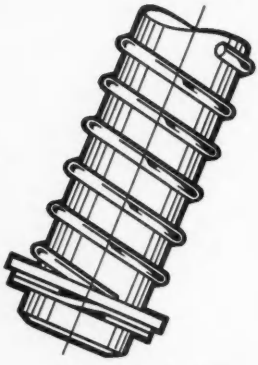
Wellworthy SPIROLOX Retaining Rings consist of two turns of flat spring steel strip formed in a continuous helix. They are concentric, with no projecting ears or lugs, and may be fitted and removed without the need for circlip pliers or other special tools. Spirolox Rings remain firm in the groove when subjected to end thrust.

Spirolox Rings are light in weight and their full circularity ensures even circumferential pressure. They are well engineered, their symmetric design ensures excellent dynamic balance for high speed shafts.

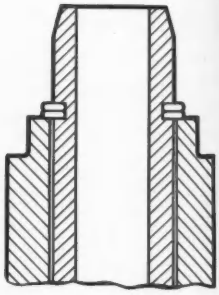
Most protective treatments can be applied to SPIROLOX Rings, including phosphate and cadmium, or they can be supplied in stainless steel.



2¼" internal Spirolox used to limit travel of sleeve in hydraulic ram, thrust 16,300 lbs.



Retains spring on shaft.



1⅛" external Spirolox for locating end movement on shaft.

Write now for full particulars and samples to Dept. ED12. Welworthy Ltd. Lymington, Hants.

WELLWORTHY
'THE CHOICE OF THE EXPERT'

SPIROLOX RETAINING RINGS
Manufactured under licence from the Ramsey Corporation, U.S.A.

THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

• *LEAF SPRINGS OF GLASS-REINFORCED PLASTIC*

In the Blue Pages for October 1959, attention was drawn to the development of glass-fibre sleeve springs. In this connection, it is now reported that directionally glass-reinforced epoxy laminates provide a material for leaf springs which, in many cases, is more efficient than steel leaf springs. By moulding a cantilever beam with up to 87% of its fibres in the bending direction, a glass-reinforced leaf spring can be designed which is twice as efficient as a steel spring of equal stiffness. In manufacturing these springs, glass rovings are coated with an accurately metered catalysed epoxy resin, so that a non-woven sheet or " ply ", 0·008 in. thick, is produced. This sheet, which is continuously manufactured like tape, has its reinforcement all in one direction. In the uncured state, the sheet is produced in large rolls as a source of individual plies for moulded sheet stock. A typical ¼-in. leaf spring produced from this material will have 30 plies after moulding, 24 of which are core plies in the bending direction; 2 plies are on each face at right-angles to provide cross-strength, with one finishing ply per face applied in the flexing direction. While high operating temperatures will affect the structural stability of all reinforced plastics, epoxy-glass laminates are noted for retaining their mechanical properties, so that springs for operating temperatures up to 250°F are available. It is expected that, with the rising temperature limits of epoxies under development, springs for correspondingly higher temperatures will also become available.

• *HEATED FORGING DIES*

A recent report points out that the relatively low temperature of dies has hitherto been an inherent limitation of press forging. A hot blank forged by a cold die loses its heat so rapidly that thin sections and completely filled deep die cavities are practically impossible to achieve. Moreover, the difficulties encountered in removing the cooled part from the die necessitate a greatly exaggerated draft. These shortcomings result in extensive and costly finishing operations to obtain the final part, so much so that it is not uncommon for the finishing costs to exceed the cost of the original forging.

With a heated die, a die material is required which retains its compressive yield strength and its resistance to corrosion at high temperatures, since, obviously, if conventional die steels heated to 1600°F press down on a stainless-steel blank heated to 2200°F, both die and blank will deform. Inconel 713C was considered suitable as a die material, but this alloy does not lend itself to die-sinking by conventional methods. A suitable method for casting the die has therefore been developed, in which the dies are assembled from four cast layers. One of the layers is provided with a series of six or seven slots, each slot becoming a container for four electric resistance-heating units. The lubricant used on the hot die is a mixture of graphite and a salt, such as potassium iodide, which is applied to the die in powder form. When the mixture is heated, the salt melts and becomes a carrier for the graphite. The use of hot dies eliminates many problems, particularly with metals which can be forged only in a narrow temperature range.

• *NON-DESTRUCTIVE ANALYSIS OF IONIZABLE GASES*

A new apparatus for the non-destructive analysis of ionizable gases and vapours is based on the fact that all elements, whether in solid, liquid, or gaseous form, when irradiated by photons of X-radiation with an energy content above that corresponding to their characteristic absorption edges, fluoresce and emit characteristic X-radiation or yield secondary electrons. The dual effect of this principle is particularly apparent when elements or compounds in the gas used as the detecting vehicle in a proportional counter are subjected to radiation by X-rays of proper energy content, giving rise to a series of electrical pulses which can be segregated into two groups and counted. The pulses in one group, called the " main " peak, result when the mechanism of secondary electron emission takes place, whereby the incident energy is utilized in the production of electrons. The pulses in the other group, called the " escape " peak, occur when fluorescence takes place, these pulses being of lower amplitude than those in the main peak. When a number of gases absorb X-radiation of sufficient energy content, there will be one main peak and a number of escape peaks arising from the emission of characteristic fluorescent radiation of different energy from the various gases. In the new apparatus, the gas is introduced into a proportional counter, which produces, as a result of the incidence of ionizing radiation, an output

Do you wait for hot water on a cold Monday morning?

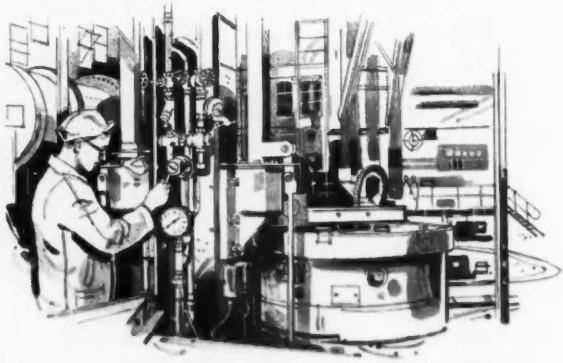
Where hot water is provided from a storage system there is a waiting period when production starts, for the water to heat up in the storage tanks.
With Leonard Steam Water Mixers there is no waiting period. Hot water is available as soon as the steam is turned on.

How would you raise the temperature of a spray very gradually from cold to 120 degrees?

Leonard Valves fitted to the sparge pipe on a cloth scouring and milling machine enable the scourer to vary the temperature to suit the work and to make changes in the temperature during the process gradually, giving a cleaner scour and a better finish.

Do you use cold water when you would like to use hot?

When vegetables are cleaned for canning they are washed in a running stream of water. If the water is too cold the girls' fingers get numb and their production slows down. If it is too hot the vegetables are spoilt. A Leonard Valve looks after the temperature, the girls' fingers and the vegetables.



These are specific examples. Your use of Leonard Thermostatic Steam Water Heaters will probably be different. Write for help. (Our folder H/24)

WALKER CROSWELLER & CO. LTD.

Cheltenham. Telephone 56317

be overcome by subjecting these lubricants to a special metallizing treatment. Basically, the lubricant comprises graphite or molybdenum disulphide in finely powdered form with an adherent deposit of discrete or discontinuous colloidal-fine particles of a metal, such as nickel, tungsten, or molybdenum, produced by a vaporizing process. Various methods of precipitating the metallic layer are possible, one of which comprises loosely pressing the graphite or molybdenum disulphide powder in a thin form on a foil carrier of, for instance, polyvinyl chloride, which is then passed slowly through a vacuum vaporizing chamber, where the exposed surface is coated with adherent particles of the metal as a result of its evaporation and subsequent condensation. It is stated that this metallized dry lubricant has the advantage that heavy rubbing in by hand is unnecessary, so that the crystals of the lubricant are not distorted during application to highly polished bearing surfaces. Furthermore, because of the metal particles, the treated graphite or molybdenum disulphide adheres more freely and rapidly to these surfaces. It is true that, owing to the metal content of the lubricant, there may be a slight tendency for it to diffuse into the bearing surfaces, but the effects of this tendency are stated to be quite harmless.

● *PRECISION INTEGRATOR FOR D.C. POTENTIALS*

Integrators of small direct currents and potentials have been put to good use in a wide variety of applications, such as in measuring photographic exposure by time-integrating the output of a photovoltaic cell, in registering watt-hours derived from the d.c. millivolt output of thermal watt converters and electronic watt converters, and in tallying the amount of gold consumed in gold-plating operations by integrating the potential drop in the plating-current shunt. A d.c. integrator has now been developed which utilizes a d.c. amplifier and a motor-driven tachometer d.c. generator providing feedback potential as its principal elements. The input circuit is free from make-and-break contacts, and the amplifier gain is very high, so that a calibration accuracy of 0·1 % is regularly achieved and potentials as low as 5 microvolts are resolved. Potentials may be of either polarity or may fluctuate back and forth through zero. Values of the integral are almost continuously registered by a mechanical counter directly driven by the motor generator. The basic principle of the integrator consists of amplifying the difference between the input potential to be time-integrated and the output potential of a small d.c. generator having a permanent-magnet field. The amplified difference controls the operation of a servomotor driving the generator. A fixed quantity of millivolt-seconds is generated at every revolution, and this is proportional only to the amount of flux cut by the revolving armature windings and the number of their turns, but is independent of speed. When the generated millivolt-seconds are fed back in series opposition to the input millivolt-seconds, the two will sooner or later balance, because any remaining difference appears as a voltage to drive the motor generator.

● *WELDING OF TITANIUM-CLAD STEEL PRESSURE VESSELS*

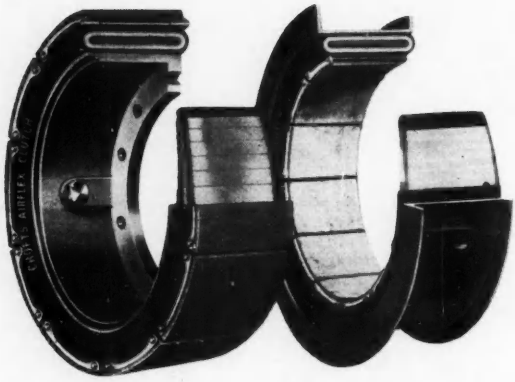
In a recent report, the forecast is made that welding techniques now available for joining titanium-clad steel may well lead to a greater use of titanium and titanium-clad vessels in the chemical, petrochemical, paper, and other processing industries. This forecast is based on the successful fabrication by welding of a pressure vessel of ½-in. mild-steel plate clad by vacuum-bonding with titanium sheet of 0·078 in. thickness. In fabricating this vessel, strong and ductile bonds were achieved between the large mating surfaces of the titanium cladding sheet and the steel backing plate. A weld joint was developed in which the titanium and the steel were not directly joined by welds, as steel-to-titanium fusion welds are extremely brittle. In bonding the titanium to the steel, braze metal is applied to the plate and the cladding metal is positioned. Then, using special equipment, the assembly is heated while pressure is exerted on the exterior surfaces, a high vacuum being maintained between the two metals. Aside from joining the two materials, the brazing metal prevents contamination of the titanium by the steel. The segmental head pieces of the vessel were formed warm in order to avoid springback, and a special welding technique was evolved for closing the titanium-steel composite seams, involving a silver inlay at the steel joint capped with a titanium cover-strap. This strap method combines weld strength for design considerations, freedom from notches or brittleness, and complete containment of the vessel contents by uncontaminated titanium-to-titanium fillet welds. All inlay welds were examined for soundness. The load-bearing steel welds were examined by X-rays before applying the silver inlay and the titanium strap. The vessel is designed to operate at 150 psi and 500°F.

For a further selection of items, please see our "Minidigest" section on pages A2, A4, and A6.

Wherever power is used Croft's Clutches play a vital role . . .

CROFT'S AIRFLEX CLUTCHES AND BRAKES

Fractional to thousands of horsepower— PUBLICATION N/573



- Fingertip control, air-actuated; ideal for remote control.
- Instant stoppage of heaviest machinery with Airflex Brakes.
- Completely reliable, no adjustment needed.
- Controlled acceleration, instant full power, creeping or inching as desired.

CROFTS (ENGINEERS) LIMITED

POWER TRANSMISSION ENGINEERS

Head Office: Thornbury Bradford 3 Yorkshire

Phone: 65251 (20 lines) Grams: 'Crofters Bradford Telex' Telex 51186

Branches at: Belfast, Birmingham, Bristol, Cardiff, Dublin, Glasgow, Ipswich, Leeds, Liverpool, London, Manchester, Newcastle, Northampton, Nottingham, Sheffield, Stoke-on-Trent.

Subsidiary Companies in Canada, South Africa, and U.S.A.

WORLD-WIDE REPRESENTATION

pulse proportional in amplitude to the energy of the radiation. The counter is fitted with a pair of spaced electrodes, to which a potential difference, sufficient to produce proportional counting action during ionization of the gas, is applied. The gas is ionized by irradiation with a monochromatic radiation source, thus producing a number of pulses of different amplitudes. These pulse amplitudes are then analysed to detect the escape and main peaks corresponding to the elements in the gas, measurement of these peaks determining its constitution.

• *ZONE-MELTING OF BORON*

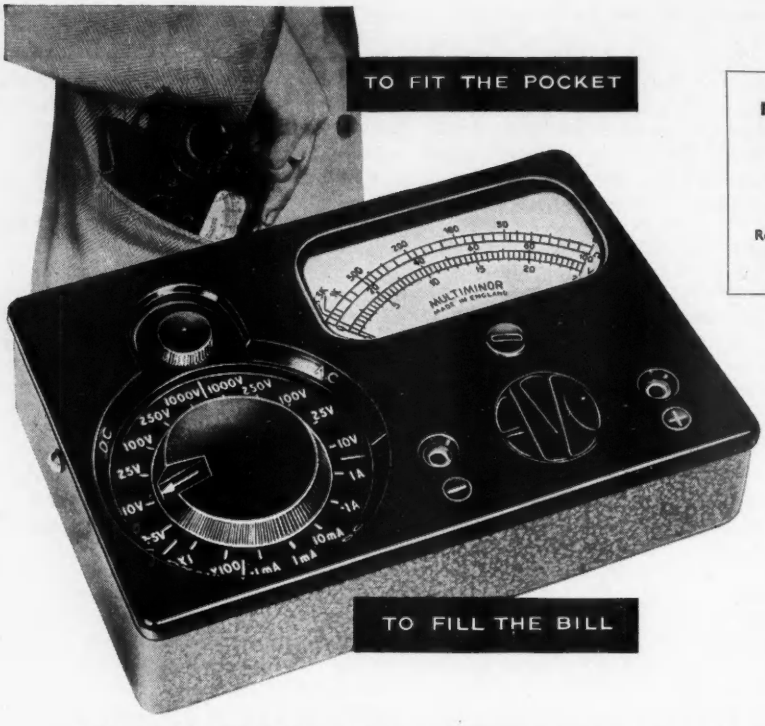
The discovery of a method of pressing rods of commercial powdered boron has led to the successful floating zone-melting of this extremely high-melting element. It is believed that the new technique will provide larger crystals for basic research studies of this semiconductor material. Because of its physical properties, boron does not normally lend itself to floating zone-melting, since it is not possible to form the powder into a suitable shape by pressure alone, the pressed forms being so friable that they crumble as soon as any attempt is made to remove them from the forming dies. In the new technique, boron powder is placed in a boiling solution of boric acid, and the mixture is boiled to dryness, causing the boron granules to become coated with boric acid. The powder can then be pressed into forms which can be handled without breaking. The formed bars are heated in two stages in a vacuum for one hour, at a temperature of 300 to 600°C, so as to decompose the boric acid into boron oxide, this compound forming a liquid coating on the boron particles. When the bar is cooled, this liquid hardens and bonds the powder into a strong bar. The bar of boron powder is mounted vertically for floating zone-melting, and a high-frequency induction coil is used to melt a narrow band or zone of the material. The molten zone is moved down the rod by raising the bar through the coil, while the melted boron freezes or crystallizes above the coil. During this operation, the boron oxide binder sublimes before the melting point of boron, i.e., about 2000°C, is reached. It is stated that crystals as large as 0·1 in. across have been obtained with this new method, many of which are twinned.

• *ELECTRO-DYNAMOMETER*

A new electro-dynamometer has been developed for use as a product resolver for the multiplication of two electrical inputs to produce an output current accurately related to the product of the two input currents. The capabilities of this unit include the measurement of voltage, current, and power with 0·1% rated accuracy on direct current and alternating current up to 2500 cps. The transfer error between direct and alternating current is less than 0·04%, with a readability and resolution better than 0·02%. Response is claimed to be fast, and power loss is less than that of a conventional dynamometer. The product resolver consists of a dynamometer mechanism and a permanent-magnet mechanism with their moving coils mounted on a common staff. The torque of the dynamometer element is automatically balanced by a current fed back into the d.c. moving coil from a d.c. amplifier, arranged to produce the counter-torque which keeps the system in balance. The d.c. mechanism is equipped with powdered-iron inserts set into solid-iron pole-pieces and core. The magnet produces a steady flux linking the moving coil by the solid iron structure, a 200-kcs field being produced in the powdered-iron inserts by means of the induction field coils attached to the magnet structure. The excitation for the induction field is supplied by an oscillator, which also amplifies any a.c. signal induced in the moving coil. As current is applied to the dynamometer coils, a torque is produced, causing the moving element to turn. The d.c. moving coil then links the 200-kcs flux and produces a signal which is amplified, rectified, measured, and fed back as a direct current to produce a torque exactly equal to the dynamometer torque.

• *RESISTANCE WELDING OF VINYL-COATED STEEL*

For the welding of vinyl-coated steel, extremely short welding-current flow times are required, e.g., about 5 to 25 milliseconds. Also, it is essential that the maximum clamping pressure on the work should be exerted at an exact predetermined time during flow of the welding current, depending on the particular welding operation to be performed. However, conventional hydraulic or mechanical actuation of the electrodes is not always satisfactory for this purpose, because they are too slow to follow the softening of the metal. Similarly, magnetic clamping equipment can be unsatisfactory, as the pressure produced lags behind the flow of the welding current. To obviate these difficulties, an improved resistance-welding process proposes to initiate and control the magnetic force used for imposing the required clamping pressure separately from the welding-current flow. In this way, maximum pressure can be applied to the work at a predetermined time and is controlled by a special mechanism. A second control is provided for controlling the flow of the current to the welding electrodes, and frequently this control will be set so that the flow of welding current will be initiated after the magnetic clamping device has been energized. Both the energizing of the clamping device and the flow of



PHYSICAL SOCIETY EXHIBITION

January 18th—22nd

Stand No. 90

Royal Horticultural Halls
London, S.W.1.

This splendid AVO instrument has been developed to meet a definite demand for a sturdy pocket-size multi-range test meter at a modest price, suitable for use on modern electronic apparatus as well as for radio and television receivers, motor vehicles and all kinds of domestic appliances and workshop equipment.

Readings are obtainable quickly and easily on a very open scale, and range selection is by means of a robust clearly marked rotary switch of the characteristic AvoMeter type. Measurements of A.C. and D.C. Voltage, D.C. Current, and Resistance are made by means of only two connection sockets.

19 Ranges

D.C. Voltage	A.C. Voltage
0— 100mV.	0— 10 V.
0— 2.5 V.	0— 25 V.
0— 10 V.	0— 100 V.
0— 25 V.	0— 250 V.
0— 100 V.	0— 1000 V.
0— 250 V.	
0—1000 V.	

Resistance	D.C. Current
0—20,000 Ω	0— 100μA
0—2 MΩ	0— 1mA
	0— 10mA
	0— 100mA
	0— 1 A

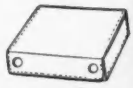
Sensitivity:
10,000 Ω/V on D.C. voltage ranges.
1,000 „ „ A.C. „ „

Accuracy:
3% of full scale value on D.C.
4% „ „ „ „ „ A.C.

List Price: **£9/10s.**
complete with Test Leads and Clips
Size: 5⅝ x 3⅜ x 1⅜ inches
Weight: 1 lb. approx.

To meet special requirements, instruments can be supplied to a higher degree of accuracy for a small additional charge.

THE MULTIMINOR



Leather Case if required 39/-

Designed and Manufactured by

AVO Ltd.

• *Write for fully descriptive leaflet*

AVOCET HOUSE · 92-96 VAUXHALL BRIDGE ROAD · LONDON · S.W.1 *VICtoria 3404 (12 lines)*
A MEMBER OF THE METAL INDUSTRIES GROUP OF COMPANIES

MM.2

welding current are so controlled that they occur in the same half-cycle of the alternating-current supply. Also, they are so timed that the maximum force of the clamping pressure is applied at the particular instant during welding-current flow when it will be most effective for obtaining the required weld. Hydraulic or mechanical equipment to set up a preliminary pressure prior to actuation of the magnetic clamping device can also be provided.

• *FUEL CELLS UTILIZING LIQUID FUELS*

A recent patent envisages the production of electrical energy in a fuel cell from a liquid fuel. In fuel cells of this kind, electrical energy is produced where the fuel, electrolyte, and fuel electrode meet, the three-phase boundary alone being electrochemically active. Fuel cells have been developed with a porous fuel electrode through which the fuel enters, meeting the electrolyte in the pores of the electrode. In contrast with such designs, the new cell is so constructed that the area of the three-phase boundary is extended within the body of the porous fuel electrode, so as to make available a greater current density than has hitherto been obtainable. Briefly, the characteristic features of the new cell are that the combustible liquid is intimately mixed with the liquid electrolyte and that the oxygen electrode of the cell is inert to this mixture. Operation of this cell is not limited to such liquid fuels as methyl alcohol and ethyl alcohol, which are readily miscible with the electrolyte; in fact, liquid fuels which are insoluble in the aqueous electrolyte, such as diesel oil, can be used by mixing them with an emulsifying agent or solubilizer such as a neutral soap. About 10% by weight of such a solubilizer also imparts electrical conductivity to a low-cost fuel. It is not only the solubilizer which is consumed when current is produced by the cell, but also the fuel itself. The addition of the liquid fuel, which is generally a poor electrical conductor, increases the specific resistance of the electrolyte, but an increase in fuel concentration speeds up the reactions at the fuel electrode and so decreases the resistance due to polarization. There is thus an optimum fuel concentration which gives maximum efficiency.

• *NEW FILM DEPOSITS FOR IMPROVING RESISTORS*

In the past decade, thin-film technology has improved such electronic components as resistors, potentiometers, photoconductors, resistance thermometers, and even windshield heaters. These improvements have included reduction in size, greater precision, and higher speeds, as well as the provision of benefits such as transparency in conjunction with low resistance. It is reported that recent research has brought to light additional materials which promise to complement and extend the advantages already provided by existing films. Among these materials are certain nitrides, silicides, and oxides. Of the nitrides studied, chromium-titanium nitride is stated to be the most promising for resistive applications. By adjusting film thickness and nitriding temperature, it is possible to obtain a wide range of resistances, which can be further extended by masking, spiralling, or meandering. Evaluations indicate that the materials possess electrical, physical, and mechanical properties for high-temperature precision-resistor uses. Chromium-silicon films appear to be more stable than the nitride films, as they do not change appreciably in resistance, even when heated in air to about 500°F, for very long periods. Most interesting were films deposited from 24% chromium and 76% silicon by weight, in which depending on the temperature of the subtrate on which the film is deposited and the thickness of the film, resistance can be varied over a range of 100:1. Investigation of these chromium-silicon films has, however, not yet been completed. Indium oxide, when formed as a film, has high transmittance and low resistance characteristics; in addition, it is rugged, so that it is useful as a transparent electrode. Films of indium oxide have also been fabricated as transparent heaters, and their use in this application is particularly feasible, as they can be applied to a substrate without heating the film or the substrate to more than 300°F. These films can be applied safely to plastics, e.g., to plastic-bonded materials used in electroluminiscent applications.

• *IMPROVED DRY LUBRICANTS FOR HIGHLY POLISHED METAL SURFACES*

The natural adhesion and hence the lubricating power of such dry lubricants as graphite and molybdenum disulphide depend on their ability to adhere at the discontinuities of the lattice structure of the crystallite of the bearing surfaces to which they are applied. This adhesion takes place either mechanically or by forces of local attraction and, in the case of highly polished metal surfaces, the conditions for such adhesion naturally become more unfavourable. However, according to a recently patented process of producing dry lubricants made of graphite or molybdenum disulphide, particularly for use with highly polished bearing surfaces of such metals as nickel and titanium, and of chromium, manganese, vanadium, or stainless steels, this difficulty can

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.

Do you wait for hot water on a cold Monday morning?

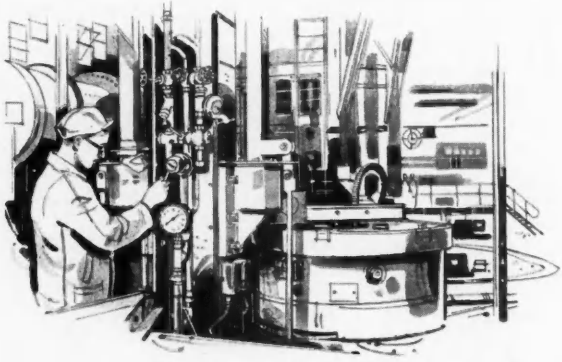
Where hot water is provided from a storage system there is a waiting period when production starts, for the water to heat up in the storage tanks.
With Leonard Steam Water Mixers there is no waiting period. Hot water is available as soon as the steam is turned on.

How would you raise the temperature of a spray very gradually from cold to 120 degrees?

Leonard Valves fitted to the sparge pipe on a cloth scouring and milling machine enable the scourer to vary the temperature to suit the work and to make changes in the temperature during the process gradually, giving a cleaner scour and a better finish.

Do you use cold water when you would like to use hot?

When vegetables are cleaned for canning they are washed in a running stream of water. If the water is too cold the girls' fingers get numb and their production slows down. If it is too hot the vegetables are spoilt. A Leonard Valve looks after the temperature, the girls' fingers and the vegetables.



These are specific examples. Your use of Leonard Thermostatic Steam Water Heaters will probably be different. Write for help. (Our folder H/24)

WALKER CROSWELLER & CO. LTD.

Cheltenham. Telephone 56317

be overcome by subjecting these lubricants to a special metallizing treatment. Basically, the lubricant comprises graphite or molybdenum disulphide in finely powdered form with an adherent deposit of discrete or discontinuous colloidal-fine particles of a metal, such as nickel, tungsten, or molybdenum, produced by a vaporizing process. Various methods of precipitating the metallic layer are possible, one of which comprises loosely pressing the graphite or molybdenum disulphide powder in a thin form on a foil carrier of, for instance, polyvinyl chloride, which is then passed slowly through a vacuum vaporizing chamber, where the exposed surface is coated with adherent particles of the metal as a result of its evaporation and subsequent condensation. It is stated that this metallized dry lubricant has the advantage that heavy rubbing in by hand is unnecessary, so that the crystals of the lubricant are not distorted during application to highly polished bearing surfaces. Furthermore, because of the metal particles, the treated graphite or molybdenum disulphide adheres more freely and rapidly to these surfaces. It is true that, owing to the metal content of the lubricant, there may be a slight tendency for it to diffuse into the bearing surfaces, but the effects of this tendency are stated to be quite harmless.

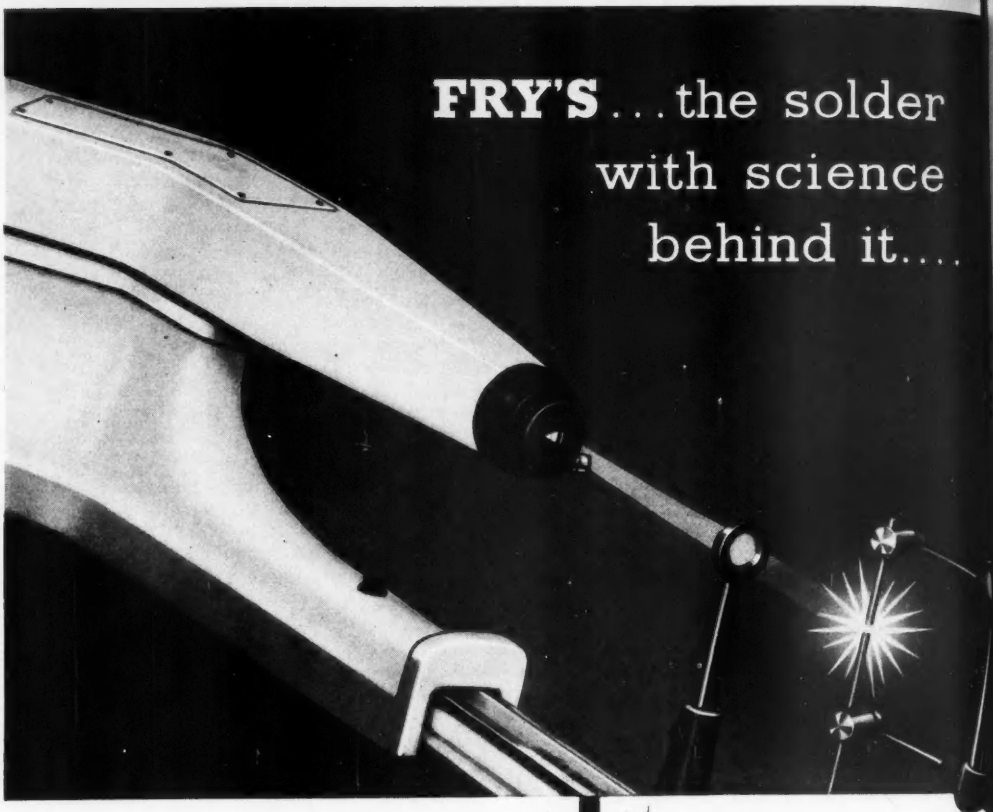
● *PRECISION INTEGRATOR FOR D.C. POTENTIALS*

Integrators of small direct currents and potentials have been put to good use in a wide variety of applications, such as in measuring photographic exposure by time-integrating the output of a photovoltaic cell, in registering watt-hours derived from the d.c. millivolt output of thermal watt converters and electronic watt converters, and in tallying the amount of gold consumed in gold-plating operations by integrating the potential drop in the plating-current shunt. A d.c. integrator has now been developed which utilizes a d.c. amplifier and a motor-driven tachometer d.c. generator providing feedback potential as its principal elements. The input circuit is free from make-and-break contacts, and the amplifier gain is very high, so that a calibration accuracy of 0·1 % is regularly achieved and potentials as low as 5 microvolts are resolved. Potentials may be of either polarity or may fluctuate back and forth through zero. Values of the integral are almost continuously registered by a mechanical counter directly driven by the motor generator. The basic principle of the integrator consists of amplifying the difference between the input potential to be time-integrated and the output potential of a small d.c. generator having a permanent-magnet field. The amplified difference controls the operation of a servomotor driving the generator. A fixed quantity of millivolt-seconds is generated at every revolution, and this is proportional only to the amount of flux cut by the revolving armature windings and the number of their turns, but is independent of speed. When the generated millivolt-seconds are fed back in series opposition to the input millivolt-seconds, the two will sooner or later balance, because any remaining difference appears as a voltage to drive the motor generator.

● *WELDING OF TITANIUM-CLAD STEEL PRESSURE VESSELS*

In a recent report, the forecast is made that welding techniques now available for joining titanium-clad steel may well lead to a greater use of titanium and titanium-clad vessels in the chemical, petrochemical, paper, and other processing industries. This forecast is based on the successful fabrication by welding of a pressure vessel of ½-in. mild-steel plate clad by vacuum-bonding with titanium sheet of 0·078 in. thickness. In fabricating this vessel, strong and ductile bonds were achieved between the large mating surfaces of the titanium cladding sheet and the steel backing plate. A weld joint was developed in which the titanium and the steel were not directly joined by welds, as steel-to-titanium fusion welds are extremely brittle. In bonding the titanium to the steel, braze metal is applied to the plate and the cladding metal is positioned. Then, using special equipment, the assembly is heated while pressure is exerted on the exterior surfaces, a high vacuum being maintained between the two metals. Aside from joining the two materials, the brazing metal prevents contamination of the titanium by the steel. The segmental head pieces of the vessel were formed warm in order to avoid springback, and a special welding technique was evolved for closing the titanium-steel composite seams, involving a silver inlay at the steel joint capped with a titanium cover-strap. This strap method combines weld strength for design considerations, freedom from notches or brittleness, and complete containment of the vessel contents by uncontaminated titanium-to-titanium fillet welds. All inlay welds were examined for soundness. The load-bearing steel welds were examined by X-rays before applying the silver inlay and the titanium strap. The vessel is designed to operate at 150 psi and 500°F.

For a further selection of items, please see our "Minidigest" section on pages A2, A4, and A6.



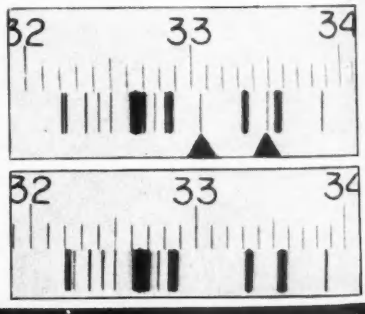
This is a routine spectrographic test carried out on every batch of FRY'S solder which leaves the works.

The spectrographic test detects harmful impurities which could mean gritty solders, causing weak or brittle joints.

This is one of the many ways FRY'S ensure that nothing but pure solders with their characteristic smooth fast bonding reach you.

ABBEY · BELFRY

In this top print the fine lines (arrowed) show zinc impurities which mar performance. The print below is free from contaminating impurities — typifying FRY'S solders.



FRY'S Metal Foundries Limited

Tandem Works, Merton Abbey, London, S.W.19
Telephone: MITcham 4023 (7 lines)

And at MANCHESTER . GLASGOW . KIDDERMINSTER . DUBLIN

MRP

ENGINEERS' DIGEST SURVEY No. 6

Universal Joints

BY

J. Shapiro, Dipl. Ing., A.F.R.Ae.S., A.M.I.Mech.E.

ANNOUNCEMENT
Laycock Engineering Limited wish to announce that from 1st January 1960, Layrub Flexible Couplings will be available for general industrial use.
As the original designers and producers of this coupling, we shall be pleased to offer full advice for its use in every form of industrial transmission however large—however small.
The Layrub Coupling needs no lubrication and it provides vibrationless, trouble-free, full transmission of power in all conditions.
LAYCOCK ENGINEERING LTD
(Dept ED)
Victoria Works · Millhouses · SHEFFIELD 8
Member of the Birfield Group

LAYRUB

flexible couplings for

INDUSTRY

CONTENTS

	Page
INTRODUCTION	479
KINEMATICS OF UNIVERSAL JOINTS	
Basic Principle of Hooke's or Cardan Joints	479
Basic Principle of Constant-Velocity Joints	480
Types of Hooke's Joints	
Simple Cross-Pin Joints	480
Needle-Bearing Universal Joints	480
Universal Ball Joints	481
Cardan Universal Joints with Gimbal Rings	482
Flexible Couplings as Universal Joints	482
Double or Close-Coupled Universal Joints	483
Types of Constant-Velocity Universal Joints	
The " Tracta " Joint	483
The Bendix-Weiss Joint	484
The Rzeppa (or Birfield) Joint	484
The Chobham (or Garringtons) Joint	485
FUNCTIONAL AND DESIGN CONSIDERATIONS	
Constant- or Variable-Velocity Output	
Torque Fluctuations	486
Consequences of Speed Fluctuations	487
Installation Features	
Low-Angle and High-Angle Designs	487
The " Lineta Uni-Joint "	488
Agricultural-Type Universal Joints	488

	Page
FUNCTIONAL AND DESIGN CONSIDERATIONS (Continued)	
Rzeppa Disc-Type Universal Joints	489
Self-Centring Properties of Universal Joints	489
Constant or Variable Length	
Accommodation of Length Variations	490
Joints with Inherent Axial Freedom	490
STATIC AND DYNAMIC FORCES	
Methods of Rating Universal Joints	491
Wear Life	491
False Brinelling	491
Torque-Correction Factor for Angularity	491
Dependence of Torque Capacity on Rotational Speed	491
Bending Vibrations	491
Effect of Forces Developed on Efficiency of Joints	
Friction Losses	492
High-Efficiency Joints	492
LUBRICATION	
Methods of Lubrication	492
Protection of Contact Surfaces	492
ACKNOWLEDGMENTS	492

E ELEMENTS

OF EFFICIENT

IGULAR DRIVES

A.R.B. approved

92-98% efficient—
N.P.L. certified

Used by leading engineering companies in every industry

For shaft diameters $\frac{1}{4}$" to $1\frac{5}{8}$"

Dirt-excluding covers can be supplied.

UNIVERSAL

BALL JOINTS

Sturdy, reliable, compact couplings of simple design, manufactured from high-grade materials, and available with single or double joints in nine standard sizes.

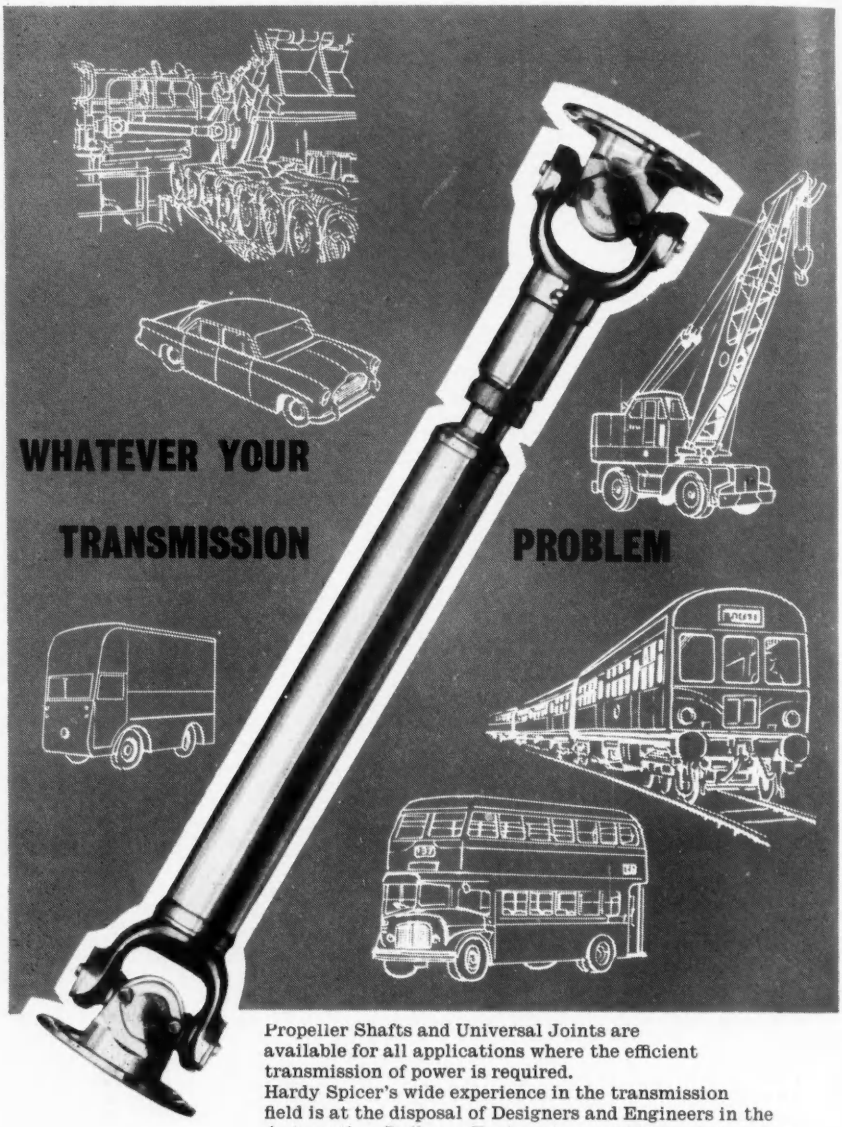
Also available in stainless and other steels.

A.M. Gauge-Test House Authority No. 89755/31

OLLART ENGINEERING COMPANY LIMITED

STON-BY-PASS SURBITON SURREY · TELEPHONE: ELMBRIDGE 0033-7 · TELEGRAMS: PRECISION SURBITON

P.2131



Propeller Shafts and Universal Joints are available for all applications where the efficient transmission of power is required.
Hardy Spicer's wide experience in the transmission field is at the disposal of Designers and Engineers in the Automotive, Railway, Engineering and Marine Industries.

A complete range of technical literature is available on request.

HARDY SPICER

PROPELLER SHAFTS

MEMBER OF THE BIRFIELD GROUP

HARDY SPICER LIMITED

CHESTER RD., ERDINGTON, BIRMINGHAM, 24 *Tel: Erdington 2191 (18 lines)*

Universal Joints

By J. SHAPIRO, Dipl. Ing., A.F.R.Ae.S., A.M.I.Mech.E.

THE term "universal joint" has acquired by convention a well-defined meaning, but logically it is not a happy choice. The generic word "joint" is unnecessarily wide, since it includes, amongst others, welded joints and pipe joints. The proper generic term should really be "shaft coupling", because universal joints are units used for the connection of rotating shafts. If a joint is described as *universal*, the implication should be that there is truly universal freedom between the shafts, whereas, by convention, a universal joint merely permits angular freedom between two rotating shafts whose axes intersect. If two shafts do not rotate, a single hinge between connecting fittings attached to their ends is enough to give the same freedom but, when they rotate, at least two hinges are necessary. The term "universal" therefore denotes "double-hinged", and a universal joint could perhaps be more aptly described as a double-hinged shaft coupling. Historically, the first universal joint was, in fact, a cross-hinged coupling, also known as a Hooke's joint. Later, many variants and alternatives were grouped under the same name, provided that they fulfilled the same function.

The universal joint borders on other machine elements of either similar design or related purpose, and it is useful to define the limits of the universal joint proper. By accepted custom, universal joints are shaft-coupling elements which can accommodate between the shafts relatively large angles, somewhat arbitrarily considered to be a minimum of about 3 deg., though it is true that they can also be used for smaller angles. It is this minimum angularity of about 3 deg. which distinguishes the universal joint from the self-aligning or flexible coupling, in which the angle concerned is usually less than 3 deg. It can also be said that, in general, a universal joint is used when the angularity between the shafts is intentional, as distinct from flexible couplings, which are used to accommodate inevitable misalignments. Furthermore, in addition to angular misalignment, a flexible coupling can accommodate parallel misalignment of the shafts, whereas a true universal joint usually cannot.

The next limitation distinguishes the universal joint from the ball joint. The latter element, also known as the ball-and-socket or ball hinge, is suitable only for the transmission of axial forces in the elements whose ends it connects. The function of a universal joint is to transmit torque. The classical Hooke's joint transmits both axial forces and torque, but, if used as a universal joint, its purpose is the transmission of driving torque. The transmission of axial forces is incidental and often specifically prevented by the method of connecting the universal joint to the shaft. Other varieties of universal joint may not transmit axial forces at all.

Still another limitation of the proper field of the universal joint is the feature of concentrating the angular freedom at the point of intersection of the shaft axes. This restriction must be accepted with qualifications, but the feature of greatly concentrated hinging remains and distinguishes the universal joint from, say, a length of flexible shaft.

Finally, it is the function of universal joints to accommodate a built-in angularity between shafts, together with occasional or periodic variations of this angularity. In this way, the universal joint differs from the 1 : 1 bevel-gear train.

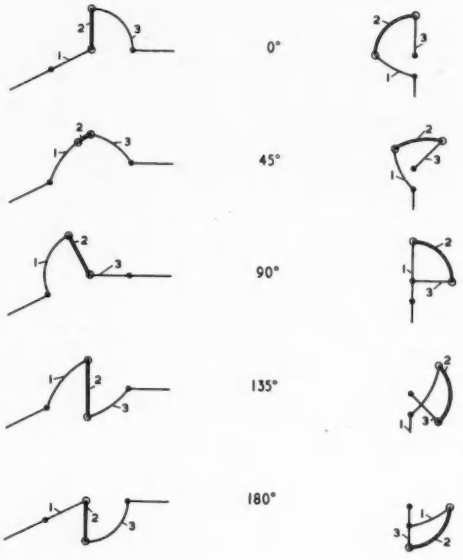
On the fringes of the universal joint as a group of machine elements, there are certain designs which trespass one or other of these restrictions. In this connection, when dealing with a considerable variety of designs, it is often convenient to adopt more than one classification principle, even though such principles overlap. For this reason, it has been considered desirable to treat universal joints, first by reviewing their kinematic principles, and then by listing their functional and installation requirements.

Kinematics of Universal Joints

The significant kinematic classification divides all universal joints into two classes which, for brevity, may be called the Hooke's (or Cardan) joint and the C.V. (constant-velocity) joint. These are somewhat colloquial names and, for clarity, a better designation would be "fixed-arm couplings" and "variable-arm couplings".

Fig. 1 shows the bare essentials of the fixed-arm coupling, in which the connecting link (2) between the two fixed arms (1) and (3) changes its position in space as the two shafts rotate through 180 deg., as shown. It is immediately clear that the mechanical advantage of one shaft over the other is different in the two extreme positions, so that, if the shafts were static, they would be in equilibrium at unequal shaft torques in two of the four positions shown. Such an elementary joint by itself therefore gives rise to periodic fluctuations in the torque ratio. Since the whole power (apart from normally very small losses) is transmitted from one shaft to the other, a torque fluctuation is accompanied by a corresponding speed fluctuation.

Such speed and torque fluctuations are rarely acceptable and must either be compensated or eliminated. For compensation, it is necessary to introduce equal and opposite variations by the use of two joints. The radical remedy is to depart from the fixed arm and to vary the coupling arm in such a manner that the mechanical



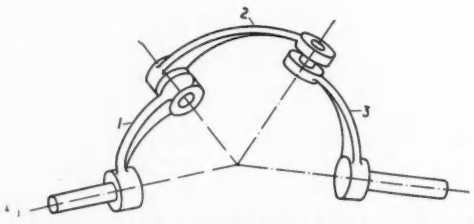


Fig. 1. Kinematic principle and various positions of the fixed-arm shaft coupling.

advantage between the two shafts remains constant during rotation of the shafts. It is clear from Fig. 2, which illustrated the kinematic principle of the variable-arm coupling, that the simple condition of geometry arising from this requirement is that the driving arm on each shaft is engaged at a point of the plane bisecting the angle between the two shaft axes. A simple embodiment of this condition is the engagement between two knife-edges, as shown in the illustration. Every so-called constant-velocity joint constitutes some practical embodiment on the same condition.

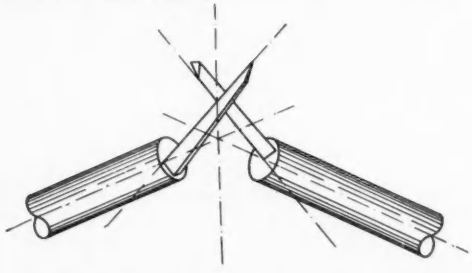


Fig. 2. Kinematic principle of the variable-arm shaft coupling.

Fig. 3. Mollart Hooke's-type universal joint.
(*Courtesy of The Mollart Engineering Co. Ltd.*)

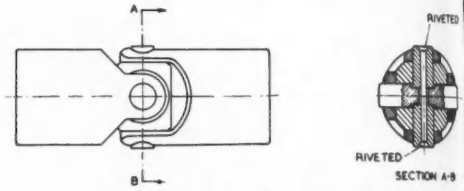


Fig. 4. Loewe Hooke's-type universal joint.
(*Courtesy of Ludwig Loewe & Co. A.G.*)

The most straightforward embodiment of the fixed-arm principle is the classic Hooke's joint with a simple cross-pin member forming the link between the fixed arms. There are two fixed arms on each shaft end, and the four intermediate links are combined in a single cross-pin component. An example of this design is the universal joint produced in England by the Mollart Engineering Co. Ltd. and illustrated in Fig. 3. Another example is the universal joint manufactured in Germany by Loewe (Fig. 4). The most prominent alternative embodiment of the Hooke's joint, made in England by Hardy, Spicer Ltd., who are associated with the Spicer Manufacturing Division of the Dana Corporation in the U.S.A. and also with Glaenzer Spicer in France, is the universal joint particularly intended for use in motor cars, in which the shaft arms carry needle bearings around the trunnions of the cross-pin member, as shown in Fig. 5. Similar joints

Fig. 5. Hardy-Spicer needle-bearing Hooke's-type universal joint.
(*Courtesy of Hardy, Spicer Ltd.*)

Fig. 6. **Moss series-C needle-bearing Hooke's-type universal joint.** (*Courtesy of The Moss Gear Co. Ltd.*)

for automotive applications are also made by the B.R.D. Co. Ltd., of Aldridge.

Of somewhat similar design is the range of " Mechanics " universal joints, series C, for automotive and industrial equipment up to about 250 hp, and for a maximum angularity of about 20 deg., manufactured in the U.K. by the Moss Gear Co. Ltd. and similar to the range produced in the U.S.A. by the Mechanics Universal Joint Division of the Borg-Warner Corporation. A typical needle-bearing universal joint of this type is illustrated in Fig. 6.

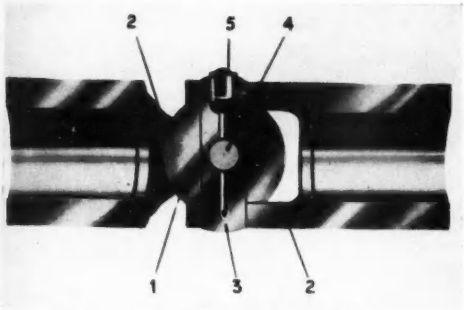


Fig. 7. " **Essex** " **B-type universal ball joint.** (*Courtesy of The Motor Gear & Engineering Co. Ltd.*)

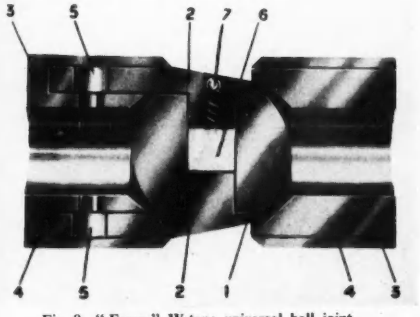


Fig. 8. " **Essex** " **W-type universal ball joint.** (*Courtesy of The Motor Gear & Engineering Co. Ltd.*)

A variant of the Hooke's-type joint is the universal ball-joint, a typical example of which is illustrated in cross-section in Fig. 7, which shows the construction of one of the larger range of B-type " Essex " joints manufactured in the U.K. by The Motor Gear & Engineering Co. Ltd. In this design, the spherical ball (1) has four flat faces ground to fit between the prongs of two forks (2), which are connected to the ball by a pair of cross-pins (3) and (4), the small-diameter pin passing through a cross-hole in the larger pin. A ball-type oiler (5), with oilways drilled in the cross-pins, ensures an adequate supply of lubricant to the working faces. Joints of this type are designed to operate satisfactorily at speeds up to 1500 rpm, depending on the working angle.

Another variant of the universal ball-joint, also made by The Motor Gear & Engineering Co. Ltd., is illustrated in cross-section in Fig. 8, which shows one of their W-type " Essex " joints, intended for use where speeds of 2000 rpm and above are required. In this design, the ball (1) is a one-piece component with four flat faces at right angles, through which two holes are provided. Links (2) seat on these faces and are positioned by pins fitting into the holes, the other ends of the links fitting into slots in the main bodies (3) and secured by pins (5) and sleeves (4) fitting over the bodies. A wool pad is provided in the hollow (6) in the ball and is supplied with lubricant via a ball-type oiler (7).

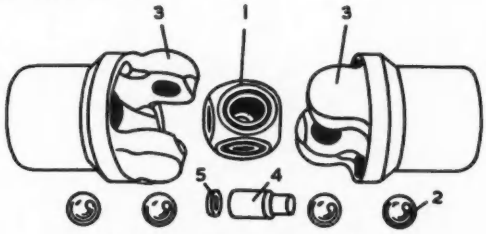


Fig. 9. " **Horstmann** " **universal joint.** (*Courtesy of Établissements Horstmann*)

Still another design in this category is the " Horstmann " joint, made in France by Établissements Horstmann, in which the central member (1) in Fig. 9 seats four balls, (2) engaging with the jaws, (3) of the driving and driven members. The balls are held in position by a special pin (4) and a cap (5).

In the universal ball-joint (Fig. 10) made, for example, by the Mollart Engineering Co. Ltd , use is made of a

Fig. 10. **Mollart slotted-type universal ball-joint.** (*Courtesy of The Mollart Engineering Co. Ltd.*)

cross-slotted ball. In this case, the two arms at the end of the shaft are replaced by a single jaw, so that the pin-and-sleeve pair of the conventional Hookes's joint becomes a jaw-and-slot pair. Clearly, torque is transmitted by a couple acting on the faces of the jaw, rather than by journal loads, as in the classic Hooke's joint.

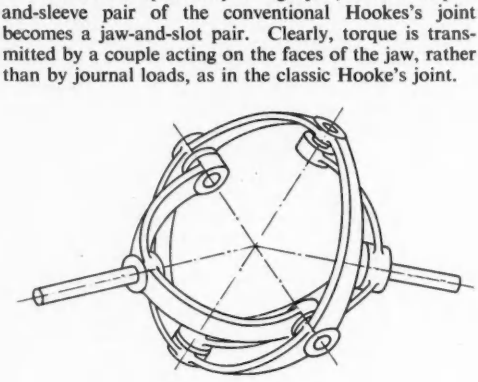


Fig. 11. Cardan universal joint with gimbal ring.

Kinematically speaking, the change from an internal cross-pin member to an external member performing the same function is of little significance. In this way, the gimbal joint is obtained (Fig. 11) in which the gimbal ring replaces the internal cross-pin member. Historically, this form of joint is more properly called the Cardan joint. An example of a universal joint embodying a gimbal ring, recently introduced by The Mollart Engineering Co. Ltd., is the " Halo Ring " joint illustrated in Fig. 12.

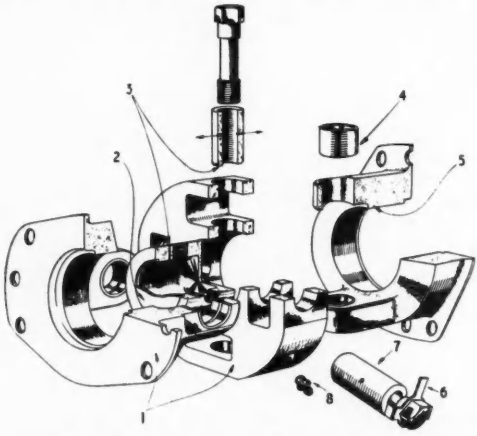


Fig. 12. Exploded view of the " Halo Ring " universal joint. (*Courtesy of The Mollart Engineering Co. Ltd.*)

(1) Fork and gimbal ring.
(2) Blanking plug, spun in line to form lubricant reservoir.
(3) Oil-hole feeds from reservoir through " nicked " bolts and bearing pins to the bearing surfaces.
(4) Thin-wall bearing.
(5) Flanged end.
(6) Locking tab-washer.
(7) Bearing pin.
(8) Grease nipple.

Though primarily designed for aircraft applications, this joint is also suitable for marine and industrial use in installations where space is a limiting factor and small angles and very high torques (up to 30,000 lb-ft) are encountered. The " Halo Ring " joint owes it strength largely to the fact that the pins carrying the load are stressed in double shear, as opposed to the usual practice in which pin bending stresses limit the loading. These joints can be supplied with thin-wall bearings or needle

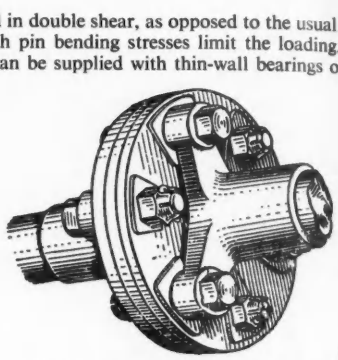


Fig. 13. Flexible non-metallic disc coupling.

roller bearings for high-speed applications (up to 7000 rpm).

A form of fixed-arm joint on the borderline between the universal joint and the flexible coupling is the flexible non-metallic disc coupling shown in Fig. 13. Although the kinematic similarity between this joint and the classic Hooke's joint is obscured by the fact that the function of the pins in the latter joint is taken over by the flexibility of the diaphragm, it nevertheless belongs to the fixed-arm definition. Its angular range is manifestly more restricted than that of the conventional Hooke's joint. The same may be said of the metallic flexible disc coupling shown in Fig. 14. This coupling, which is made in the U.K. by Metaducts Ltd., utilizes a single or double metallic laminated ring, rather than a non-metallic disc, and can accommodate a misalignment of at least 2 deg. for a double-bank arrangement.

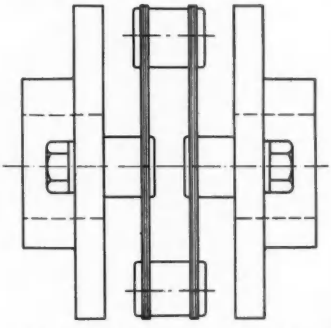


Fig. 14. " Metastream " C.N.-series type-D double-bank coupling. (*Courtesy of Metaducts Ltd.*)

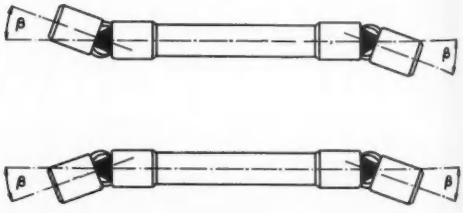


Fig. 15. Methods of overcoming torque and speed fluctuations by means of an intermediate shaft forming equal angles with the driving and driven shaft.

As stated before, the main method of overcoming torque and speed fluctuations inherent in fixed-arm designs is the association of equal but opposing fluctuations, and this can be accomplished by the installation of two consecutive joints in the same shaft transmission. Kinematically, there are two basic arrangements (Fig. 15) for achieving this purpose, in both of which the intermediate shaft forms an equal angle β with the driving and driven shafts. Also, in both arrangements, it is essential that the fork members of the joint halves on the intermediate shaft lie in the same plane, i.e., both pin axes in the fittings attached directly to the intermediate shaft must be parallel.

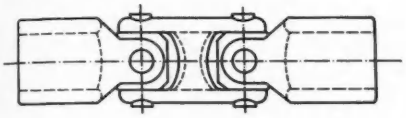


Fig. 16. **The Büco close-coupled Hooke's-type double universal joint.** (*Courtesy of Hans Bühler & Co.*)

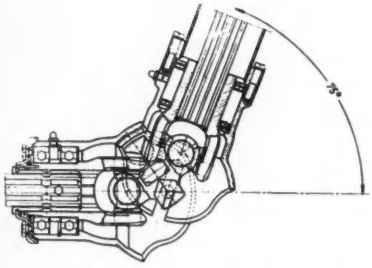


Fig. 17. **The Walterscheid close-coupled Hooke's-type double universal joint.** (*Courtesy of Jean Walterscheid*)

In many instances, the installation of such paired joints can be facilitated by the provision of twin-joint units, also known as "double universal joints" or "close-coupled universal joints", examples of which are illustrated in Figs. 16, 17, and 18.

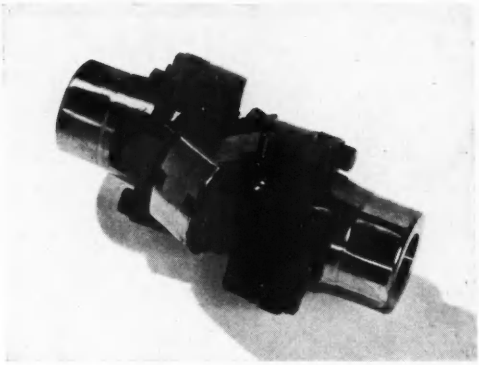


Fig. 18. **Moss series-C close-coupled Hooke's-type double universal joint.** (*Courtesy of The Moss Gear Co. Ltd.*)

A simplified design of a close-coupled universal joint achieving the shortest centre distance is the "Tracta" constant-velocity universal joint, which is manufactured in the U.K. by Girling Limited and which is used to some extent in atuomotive applications. In this joint (Fig. 19), the load-transmission elements are a slotted joint (2) and a spigotted joint (3), each held by forks (1) and (4) formed by or fitted to the ends of the driving and driven shafts. The fork jaws are closed in to less than 180 deg. (usually 120 deg.) to keep the joints in place after assembly. The joints are spherically shaped, with the outer ends flattened to reduce the overall coupling dimensions, and are grooved to fit the inner diameter of the forks, so that each joint rotates freely about its fork centre. A flat (5) is milled on the fork groove of each joint, facilitating its easy assembly into the fork.

Kinematic analysis of the Hooke's joint yields the following relation for the speed ratio ω_a/ω_b of the drive shaft *a* and the driven shaft *b*:—

$$\frac{\omega_a}{\omega_b} = \frac{\cos \alpha}{1 - \cos^2 \varphi \sin^2 \alpha}$$

where α is the angle between the shaft axes and φ is the angle of rotation of the driven shaft *b*.

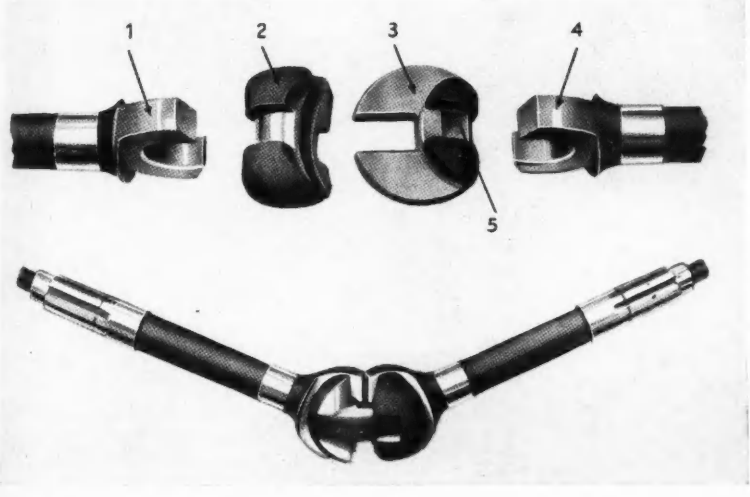


Fig. 19. **The "Tracta" constant-velocity universal joint.** (*Courtesy of Girling Ltd.*)

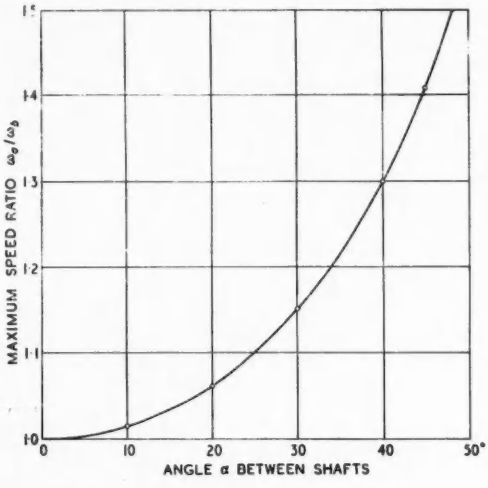


Fig. 20. Maximum speed ratio ω_a/ω_b of a Hooke's-type joint as a function of angle α between the shaft axes.

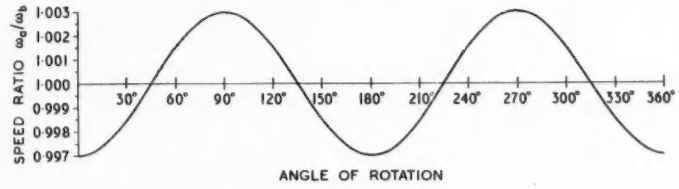


Fig. 21. Speed ratio ω_a/ω_b during one revolution of a Hooke's-type joint for an angle α between the shaft axes of 4·5 deg.

The maximum speed ratio $\omega_a/\omega_b = 1/\cos\alpha$ is plotted in Fig. 20 as a function of angle α, while speed variation during one revolution at a given angle α between the shaft axes is shown in Fig. 21, which illustrates the fact that speed fluctuation takes place at a frequency equal to twice that of shaft rotation.

It is to avoid these fluctuations in a single unit that the variable-arm type of joint, which is a true constant-velocity joint, was devised. The first markedly successful mechanism maintaining the driving load permanently in the bisecting plane was the Bendix-Weiss joint, which was incorporated in the General Motors general-purpose army-truck used in World War II. Fig. 22 shows the kinematic principle of this joint in diagrammatic form, each arm carrying a groove of semicircular cross-section, with the groove curved in an axial plane. The curve of the groove axis is laid out in such a way that the two grooves intersect on the bisecting plane, irrespective of the angle between the shafts. The design of this joint, which is made in the U.S.A. by the Bendix Products Division of the Bendix Aviation Corporation, is shown in Fig. 23, in which a ball transmits the pressure from the drive arm to the driven arm, its position being determined by the point of intersection of the groove axes, since it is embedded in both grooves.

Another design of American origin is the Rzeppa joint, now manufactured by the Con-Vel Division of the Dana Corporation, of Detroit, and also in the U.K. by Hardy Spicer under the name of the "Birfield" joint (from the Birfield Group of companies, of which Hardy, Spicer Ltd. is a member). The earlier type of Rzeppa joint (Fig. 24a), used in the original models of the famous Willys jeep, had curved grooves of semicircular cross-section in an inner driving member and also in an outer driven member. The groove axis lies in the plane containing the axis of the shaft to which it belongs, and the groove is circular, with its centre coinciding with the centre of the joint. This arrangement of grooves does not by itself fully locate the balls situated between the driving and driven grooves. Consequently, a separate cage is used, the position of which is guided by a pin arrange-

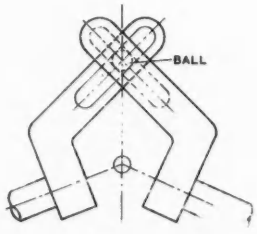


Fig. 22. Kinematic principle of the Bendix-Weiss constant-velocity universal joint.

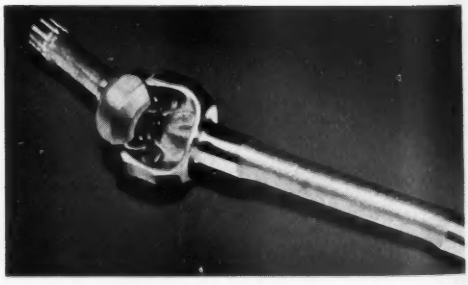
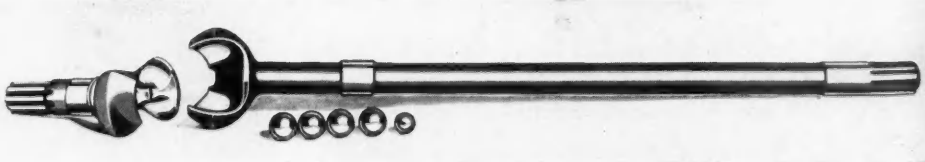


Fig. 23. Bendix-Weiss constant-velocity universal joint, shown (right) assembled, and (below) disassembled. (*Courtesy of Bendix Aviation Corp.*)



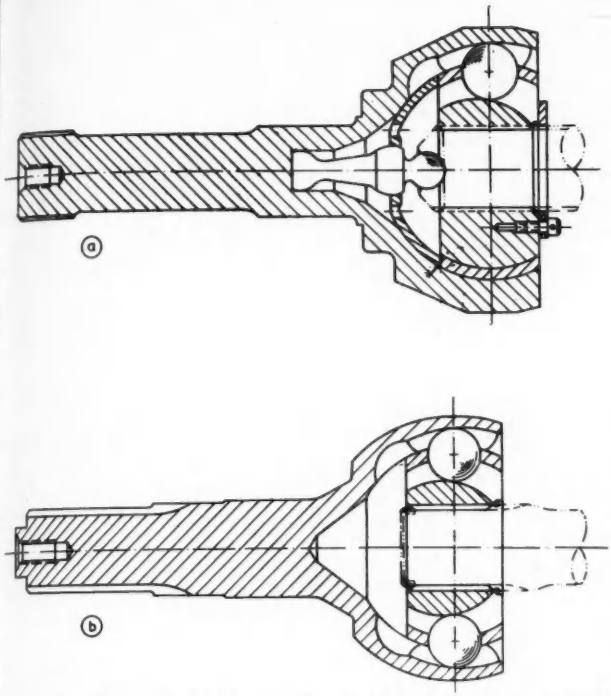


Fig. 24. The Rzeppa constant-velocity universal joint, showing (a) an earlier type and (b) a later version.

ment, as shown in Fig. 24a. The two pin ends fit into the driving- and drive-end sockets and, at an intermediate point, a spherical collar on the pin fits into a hole in the cage, thereby forcing the cage to take up a position bisecting the angle between the two shafts.

In later versions of this type of joint (Fig. 24b), the grooves are not concentric and therefore guide the ball position on the same principle as in the Bendix-Weiss joint. Six driving balls are used, all of them transmitting torque simultaneously in either direction of rotation and held by a close-fitting cage in correct alignment, with the balls in a plane bisecting the angle between the driving and the driven members. Although light in weight, the outer and inner members, which may be compared to internal and external ring gears, have extreme strength against deflection and may be considered as unbreakable, even under the highest loads. Furthermore, the complete unit can be handled, mounted, and removed without the slightest loss of internal alignment or possibility of internal disassembly, while only one shaft, either at the driving or driven end, needs to be supported.

The fundamental difference between the American Rzeppa and the British Birfield joint lies in the fact that the Rzeppa joint utilizes grooves of semicircular cross-section, whereas the grooves in the Birfield joint are of semi-elliptical cross-section. It is claimed that this modified geometry produces controlled track conformity and pressure angle of contact, resulting in improved contact conditions, as the balls are in pure compression, rather than in shear, as is the case with the Rzeppa joint. As a result, higher specific loadings are possible.

Rzeppa (or Birfield) joints are available in a wide range of sizes, up to about 22 in. in diameter, a typical rating being 6000 hp for a 16-in. joint at 900 to 2500 rpm with an angularity up to 6 deg. A feature of the British Birfield version, in the case of the very large sizes, is the incorporation of a built-in pressure pump for ensuring circulation of lubricating oil. A typical Rzeppa or Birfield bell-type universal joint is illustrated in Fig. 25.

A British design which comes closest to the simple knife-edge engagement illustrated in Fig. 2 is the Garringtons (now known as the Chobham) constant-velocity universal joint, which was originally conceived by the Fighting Vehicle Research and Development Establishment of the Ministry of Supply at Chobham to overcome transmission problems arising in the use of military vehicles, and which was initially developed and produced by Garringtons and is now manufactured by their associated company, the B.R.D. Co. Ltd., of Aldridge. The schematic arrangement of the engaging surfaces embody-

Fig. 25. The Rzeppa or "Birfield" bell-type constant-velocity universal joint.
(Courtesy of Hardy, Spicer Ltd.)

ing the knife-edge principle shown in Fig. 26, and the joint itself in Figs. 27 and 28, from which it will be seen that the Chobham joint contains no rolling elements.

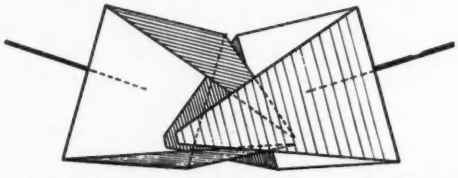


Fig.26. Schematic arrangement of the engaging surfaces of the Chobham constant-velocity universal joint.
(Courtesy of the B.R.D. Co. Ltd.)

Consisting basically of two forged-steel heads, the Chobham joint is particularly suited to vehicle applications, as it can be used at angular deflections up to 35 deg., or even more for special applications. Four uniformly spaced semi-cylindrical grooves with converging axes are machined in each head and support semi-cylindrical pads axially located by integral collars or pegs engaging in slots machined across the grooves. The axes of the pads, which are retained by spring-clips, coincide with longitudinal centre-lines of the cylindrical surfaces and are uniformly spaced. When in axial alignment and assembled together, the pads overlap, their intersection with each other forming a lozenge-shaped area, through which the load is transmitted, the angle of their convergence being so arranged that this contact area undergoes a minimum change during axial divergence of the joint halves. The axes of the pads are arranged in radial planes at 90 deg. to each other, permitting axial displacement without the introduction of backlash and, as the lozenge-shaped areas are generous with relation to the load they are intended to carry, stressing of the pads is reduced to a minimum. Although fundamentally intended for comparatively low-speed applications, e.g., up to 1000 rpm, special high-speed versions of this joint, intended for speeds between 1800 and 2000 rpm, are under development.

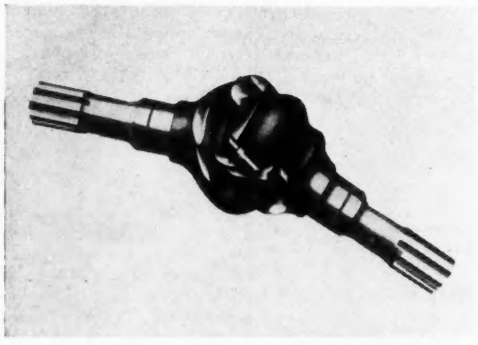


Fig. 27. Typical Chobham constant-velocity universal joint.
(Courtesy of the B.R.D. Co. Ltd.)

Functional and Design Considerations

To the designer, whose main purpose is to fulfil functional and other requirements, kinematic principles as such are of academic interest only, as attention is principally directed to the geometry of the installation, the provisions needed in the associated components for freedom of movement during operation, particulars of assembly, services, or protection required, the load and endurance capacity of the joint, and its efficiency. These points will now be discussed and will be related to the joint embodiments already illustrated, together with further examples of particular interest by virtue of their special design features.

Constant- or Variable-Velocity Output

It is rare that, in any installation of a universal joint, anything but a constant-velocity output for a constant-velocity input is acceptable. The basic kinematic subdivision into constant- and variable-velocity joints therefore becomes one of distinguishing between those joints which achieve a constant-velocity output in a single unit and those wherein constant-velocity operation is achieved by the mutual compensation provided by two units.

There are, of course, occasions where there is a definite requirement for velocity fluctuations, an example being in the case of certain dynamic test equipment, in which an alternating component of torque is required. In this connection, it is easy to provide a variable-amplitude torque fluctuation. The fluctuation is not a pure harmonic of single frequency in terms of the shaft angle of rotation, but contains a large number of harmonics with a strong predominance of the second harmonic. A typical convergence of the amplitudes of other harmonics with increasing frequency is illustrated in Fig. 29.

In other applications, speed and torque fluctuations, though undesirable, are tolerated. Sometimes, such as in manual transmissions for mechanical control, quite large fluctuations are acceptable, particularly as the input speed itself is normally not very uniform.

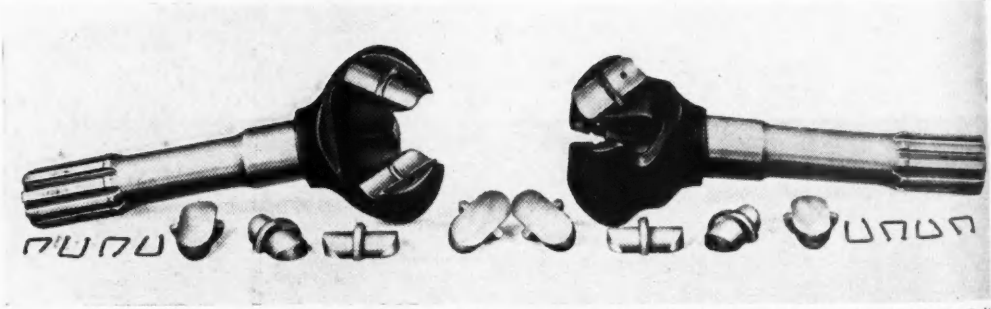


Fig. 28. Details of the Chobham constant-velocity universal joint. *(Courtesy of the B.R.D. Co. Ltd.)*

The two basic compensating layouts shown in Fig. 15 demand the fulfilment of a certain layout geometry expressed by the equality of the angles. Owing to movements of supports, this equality may be only nominally present, and residual fluctuations may easily occur.

The elastic twist of the intermediate shaft may also be responsible for errors of compensation in layouts with two joints separated by a shaft of appreciable length. The relative orientation between the two joints can thus be distorted and, in severe cases, compensation may not only be eliminated but an actual intensification may be the result.

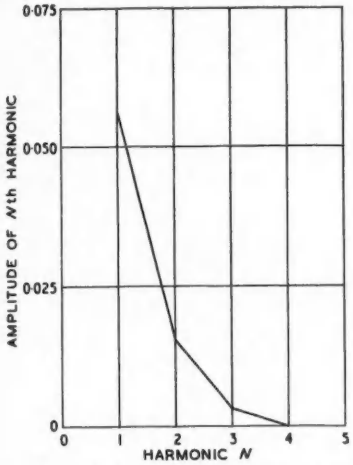


Fig. 29. **Amplitude of *N*th harmonic as a function of harmonic *N*.**

In short, the preservation of true constant output velocity cannot be guaranteed in practice in any layout which depends on the precise co-ordination of two joints. The essential advantage of the single unit lies in its compactness and in the absence of any component rotating with a non-uniform speed. In this respect, even the close-coupled twin-joint unit incorporating two Hooke's joints, such as those shown in Figs. 16, 17, and 18, cannot rival the single unit, in which the maintenance of built-in accuracy can, for all practical purposes, be guaranteed.

In other words, it must be emphasised that the required property is the constant-velocity ratio *under load*, and it is almost impossible to ensure this property with two mutually compensating Hooke's joints when they are widely separated. Neglect of this principle, which involves precise geometry under load, has given rise to many difficulties in practice.

It is appropriate at this point to enumerate briefly the consequences of speed fluctuations. In a number of applications, such consequences can be of great importance, a typical case being in machine tools, where the transmitted motion performs a co-ordinating function between two motions whose relation must be very precise. For example, a transmission incorporating universal joints may form the link between two components of a generating motion, as in a gear-cutting machine. Another typical case is that of a vehicle or similar drive, in which constant velocity at the output end is ensured by the fact that the inertia of the vehicle predominates. Any variable-ratio transmission between input and output then forces the input, i.e., the engine propeller shaft, to become non-uniform, with possible adverse effects on engine performance.

The indirect consequences of non-uniform rotation can, in some cases, be even more important. Thus, alternating stresses are introduced, and may lead to fatigue failures. Similarly, torsional vibrations, and, as will be shown later, bending vibrations, may be excited at various frequencies. In certain layouts, the transmission system may be so loaded that the possibility of self-excited vibrations arises. Even when the output motion is uniform, the intermediate shaft between the two joint units must be subject to fluctuating torsional and bending loads. It is important to realize that even quite small exciting forces can, owing to resonance, lead to quite large actual stress fluctuations.

As a result, the simplicity and cheapness of the Hooke's joint are sacrificed to the constant-velocity design, when complications such as these must be reckoned with.

Installation Features

Clearly, the universal joint must be capable of an angulation determined by the layout of the transmission. Requirements naturally differ greatly, but, as the lower limit of the universal joint has been fixed (somewhat arbitrarily) at 3 deg., it is possible to distinguish typical low-angle and high-angle designs of universal joint. In addition to flexible disc couplings of the types shown in Figs. 13 and 14, low-angle designs include other types of special couplings, such as the Standage couplings shown in Figs. 30 and 31. It should, however, be noted that, as

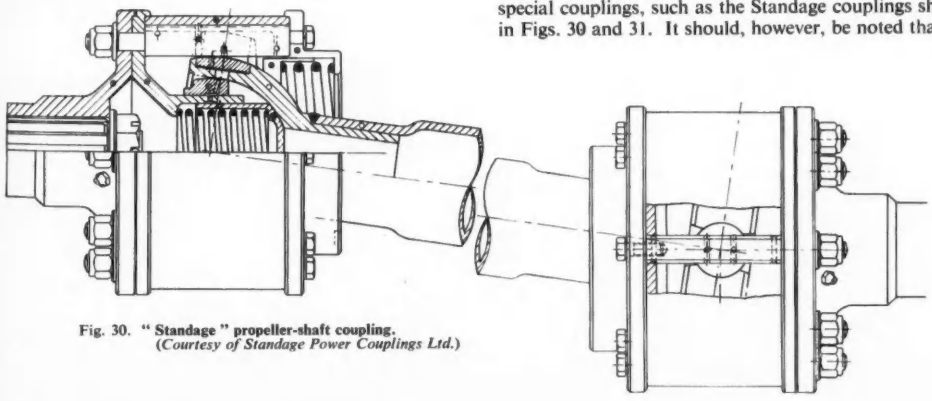


Fig. 30. **" Standage " propeller-shaft coupling.**
(*Courtesy of Standage Power Couplings Ltd.*)

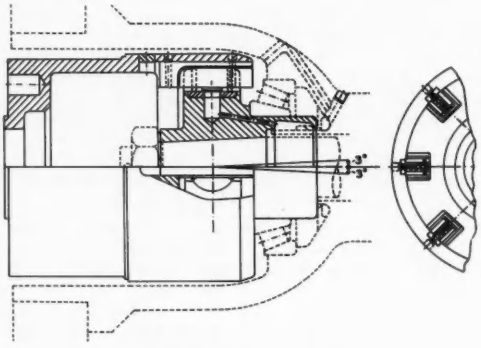


Fig. 31. " Standage " flexible-coupling type of universal joint.
(*Courtesy of Standage Power Couplings Ltd.*)

already stated, flexible-coupling types of joint cannot be designed conveniently for large angles.

Most of the other joints so far described are inherently capable of high-angle design. The common type of Hooke's joint in its commercial versions is usually advertised for angles of up to 45 deg. and more. It would, however, be most unusual to seek a greater angularity in a single Hooke's joint. As shown in Fig. 15, one of the two layouts for transmissions incorporating Hooke's joints involves halving the total angle between two joints in series to avoid speed fluctuation, even if a single Hooke's joint could manage the angle required.

In an application which imposes no demands on accuracy, e.g., in a manual control run through a torsion shaft, very severe angles may be tolerated. One such design which, from the point of view of its application, might conceivably be described as a universal joint, is illustrated in Fig. 32, and is particularly intended for

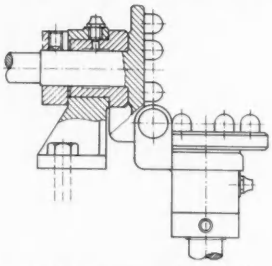


Fig. 32. The " Lineta Uni-Joint ".
(*Courtesy of Standage Power Couplings Ltd.*)

variable angularities up to 90 deg. or even a little more. Originally developed in Denmark and now available from Standage Power Couplings Ltd., this unit, which is marketed in the U.K. under the name of the " Lineta Uni-Joint ", is, from the point of view of kinematics, merely an elementary and imperfect form of bevel-gear train, and subordinate transmissions of this type are normally very lightly stressed and intermittently operated.

Frequently, permissible angularity is not determined by geometry alone. Thus, needle-bearing universal joints for automotive applications of the type made by Hardy Spicer (Fig. 5) and the Moss Gear Co. (Fig. 6) are intended for moderate angles. For other applications, such as in agricultural, road, and construction machinery, where wide-angle operation via a power take-off is often required, special joints, sometimes known as the agricultural type of joint, are available. Thus, the Moss joint illustrated in Fig. 33 is available in ratings up to 50 hp, has an angular capacity up to 90 deg., and can operate intermittently at angles up to 45 deg. Similar units are also made by Hardy Spicer (Fig. 34), who produce a range of joints of simple and light construction, with end fittings designed to accommodate an angle of 90 deg. A large assortment of these agricultural-type joints is also offered by Hardy Spicer for a maximum angle of 40 deg. under suitable conditions for intermittent operation and 20 deg. for continuous operation (Fig. 35), the difference in angularity being due to the wear life of the joint. On the other hand, there are also limitations in maximum angularity imposed by the less favourable stressing of the joint elements and by a loss in efficiency. These limitations are entirely specific to each design of joint and will be mentioned later.

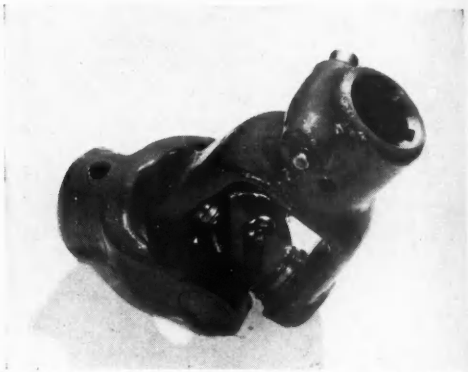


Fig. 33. Moss Series-A agricultural Hooke's-type universal joint.
(*Courtesy of The Moss Gear Co. Ltd.*)

In addition, a quick-release joint, known as the rapid coupling (Fig. 36), has also been introduced by Hardy, Spicer Ltd., and is intended to obviate the need for bolts or set-screws for the retention of the drive shaft to the power take-off of a tractor, permitting the shaft to be coupled or uncoupled in a matter of seconds without the use of tools.

In many countries, safety regulations exist governing the use of open or unguarded agricultural-type universal joints and drives employed in conjunction with power

Fig. 34. Hardy Spicer power-take-off Hooke's type universal joint with 90-deg. angular movement.
(*Courtesy of Hardy, Spicer Ltd.*)

Fig. 35. **Hardy Spicer universal joints with drive-shaft.**
(Courtesy of Hardy, Spicer Ltd.)

take-offs, such as those described above. In such cases, where accidental injury is possible with drives that are not already adequately protected, assemblies have been developed by most companies to include a cover or protective shield over the shaft. In some designs, the shield, which partially extends over the universal joints, is permanently stationary, while in others it revolves on low-friction bearings on the shaft, but comes to rest immediately when touched. An example of the latter type is shown in Fig. 37.

Fig. 36. **Hardy Spicer rapid coupling for power take-offs.**
(Courtesy of Hardy, Spicer Ltd.)

Joints of a type inherently capable of large angles can sometimes be designed more economically for specific low-angle applications. A design with many variations is the constant-velocity joint with torque transmission through balls operating in grooves. In addition to the high-angle bell-type joint shown in Fig. 24, the Rzeppa joint is also available as a disc-type joint, as shown in Fig. 38. In this design, the balls are located between a slotted star member mounted on one shaft and a slotted cylindrical member mounted on the other shaft, the balls being kept in the bisecting plane by the action of two rings which are guided on their internal spherical seatings, as shown in the illustration. An attractive application built into a motor-car rear-axle differential unit is shown in Fig. 39, this unit appearing to be exceptionally compact, considering its many functions.

On the other hand, some problems exist when incorporating universal joints with any rolling elements in a drive layout with a very low angularity. In such cases, it often happens that, during each revolution of the shaft, the rolling element, e.g., a ball or needle, is not subjected to sufficient movement to make a full revolution itself, so that it suffers unequal deformation and wear. Even more important in practice is the criterion of overlapping of the paths of the rolling elements on their races. If no overlapping occurs, a condition can exist where the rolling elements embed themselves permanently into the races, this condition being known in all oscillating bearings and colloquially called " false brinelling ". Its causes will be discussed later under the heading of joint strength.

The geometry of the universal joint also decides its self-centring property. Some joints are self-centring because of an inherent geometric feature of the transmitting elements in the joint, outstanding examples being the classic Hooke's joint with pins and, less perfectly, the Hooke's joint of the ball-and-slot type. In the constant-velocity class of joint, an example of the inherently self-centring type is the earlier design of Rzeppa joint (Fig. 24a). In the later versions of the Rzeppa joint (Fig. 24b,) the grooves in which the balls roll are no longer concentric, and self-centring is ensured by the spherical seating of the cage member. Similarly, in the Bendix-Weiss joint, the grooves provide markedly imperfect centring, and precise concentricity is obtained by incorporating a single centring ball in the middle of the joint (Fig. 23).

The Chobham or Garringtons joint may also be said to be self-centring. In this connection, the normal 8-pad Chobham joint may not possess perfect self-centring properties, depending on the extent of wear, etc., but perfect self-centring can always be obtained in this joint by the use of a 12-pad design, and the manufacturers are contemplating developments in this direction. It should, however, be noted that, in practice, the fact that the 8-pad Chobham joint is not truly self-centring under conditions of extreme wear has been found to be of no practical importance, insofar as vibration, etc., is concerned. It should also be appreciated that, irrespective of its self-

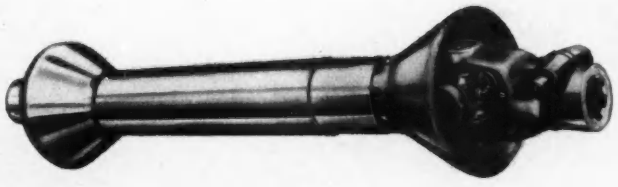


Fig. 37. **Agricultural-type universal-joint and shaft assembly with protective shield.**
(Courtesy of Hardy, Spicer Ltd.)

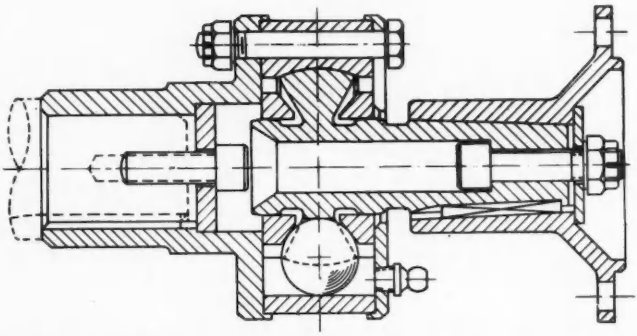


Fig. 38. Rzeppa disc-type constant-velocity universal joint for moderate angles and high speeds.

centring properties, the Chobham joint is self-supporting.

A direct application of the self-supporting property of a joint is the fact that, if two joints are installed in a transmission, the intermediate shaft between them can be supported entirely by the joints and does not require the use of any bearings. It is, however, not always practical to eliminate bearings when, from the point of view of geometric centring, none is required. When two bearings are used, the two location elements may "fight" each other and, in terms of statics, an indeterminate shaft mounting results. Very careful attention must be given to this matter, especially as the consequence of wear can be a complete redistribution of bearing loads.

Constant or Variable Length

It is important to the designer whether a length of shaft coupled at its extremity through a universal joint can or cannot accommodate small variations in length between the joint centres. The cross-pin type of Hooke's joint fixes the shaft end in space, and a variation in length can be accommodated only if the joint unit is attached to the shaft in a manner which allows axial expansion, either in operation or for assembly purposes only. In the latter case, all that is required is a type of shaft fitting whose axial position is fixed on assembly. The joint shown in Fig. 34 is designed to be keyed to the shaft, and constitutes one of several embodiments of simple Hardy Spicer joints using keys, pins, or splines.

Continuous variation in length is often necessary in agricultural machinery and, in the agricultural joint assembly already mentioned and shown in Fig. 35, a square bar drives a square tubular member.

Joints of the cross-slotted ball type have inherent axial freedom, but neither the sliding-spline, the square-shaft, nor the slotted-ball type of coupling is suitable for high-torque applications, in which continuous axial freedom must be preserved. For high-torque applications, units have recently been developed which are described as universal joints, although they might also be termed misalignment couplings. The Standage propeller shaft shown in Fig. 30 embodies one flexible coupling at each end, designed for a maximum angle of about 10 deg., and so falls within the definition of a universal joint. It should be noted that this coupling is basically a fixed-arm type and is therefore subject to speed fluctuations, so that the two end-joints of the propeller shaft must be suitably arranged for mutual compensation.

A design on the same principle is the Standage universal joint shown in Fig. 31, in which similarity with the Hooke's-joint principle is now entirely limited to the fixed-arm feature. The driving torque is transmitted through a number of projections co-operating with slots in the male part of the fitting. Although superficially the transmission proceeds through all the projections, and thus the appearance of a gear transmission with constant velocity is created, it follows from the fixed-arm principle that constant velocity is not possible. The coupling therefore yields speed fluctuations, but at a frequency much greater than twice the frequency of shaft rotation and of greatly reduced magnitude, compared with the fluctuations induced by a Hooke's joint at the same angle between the shaft axes.

Another joint which has the merit of allowing axial displacements of each half is the Chobham or Garringtons joint shown in Fig. 27. This feature is inherent in the design and does not require additional elements, while the contact surfaces over which sliding takes place are located at a relatively large distance from the axis.

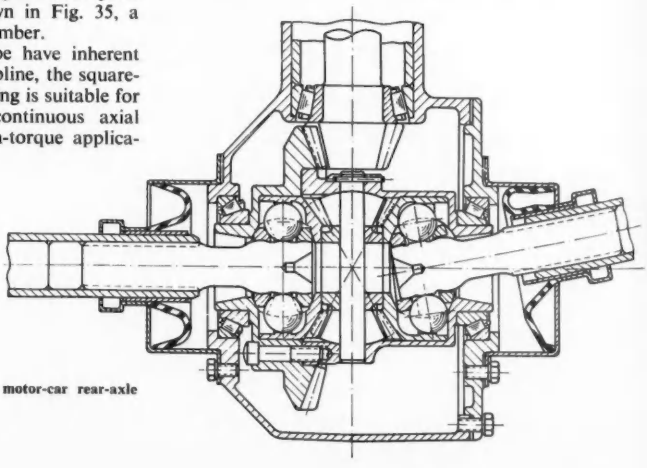


Fig. 39. Rzeppa universal joints built into a motor-car rear-axle differential unit.

Static and Dynamic Forces

The main purpose of the universal joint is the transmission of torque and, as such, the joint is rated by its torque capacity. Usually, the weak points of a joint are the surfaces subject to rolling or sliding under pressure, and, for a given torque capacity, the further such surfaces are from the axis, the less heavily loaded they become. From the point of view of torque capacity, the merit of a joint therefore depends on the torque capacity for a given outside joint diameter. However, the stiffness of the joint, as distinct from its strength, is not always helped by a large diameter.

A joint can be rated for strength, stiffness, or life, and the ratings may all be different. In practice, stiffness is rarely a determining factor, because the joint is a link in a transmission system which is usually considerably less stiff than the joint itself. When stiffness is important, or where it is desirable to reduce the overall cross-section of the joint, the compact universal ball joints of the type already described have much to recommend them, and such joints are often found in machine tools or special assemblies. Their outside diameter is only moderately larger than that of the shaft on which they are mounted, and they are also distinguished by very high precision. When neither precision nor stiffness is decisive, but a size hardly exceeding that of the shaft is essential, the slotted-ball type of joint (Fig. 10) is often used. The torque capacity of this type of joint is only a fraction of that of the shaft.

When torque capacity becomes decisive, it is the life of the joint which constitutes the first limitation, whilst strength is rarely a significant factor. For this reason, many joint fittings have far from ideal shape when considered as transmitters of forces. All joints designed for torque capacity are larger than their shaft extensions, and the ratio of the outside diameter of joint and shaft can be considered as a significant criterion of merit of any joint designed for torque. Typical ratios in the most common series of automotive Hooke's-type joints are between 2 : 1 and 4 : 1. The diameter ratio should be borne in mind when comparing different joint designs.

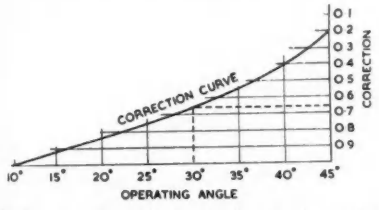


Fig. 40. **Torque-correction factor as a function of operating angle.**

Limitation by life, which invariably means wear life, introduces the effects of motion and hence of speed. Obviously, in a joint connecting coaxial shafts, there is no sliding or rolling motion at all, whereas considerable motion exists when a large angularity is present. As already mentioned, rolling elements in contact, when the motion is very small, have a limitation due to false brinelling. The significance of this phenomenon lies in the fact that it appears at values of contact stress (as derived from the elastic theory of bodies under direct contact) considerably below the maximum permissible for the material in question. There is little doubt that some chemical surface activity is present, because the phenomenon is greatly dependent on the chemical nature of the lubricant used. Certain oils and greases, particularly the latter, have an inhibiting effect, and all major manufacturers market a special brand of grease for use in bearings and joints liable to false brinelling.

Because of limitations imposed by wear life, a correction factor must be introduced, a typical curve of torque-correction factor as a function of angularity being shown in Fig. 40, which may be considered more or less representative of Hooke's-type joints and constant-velocity joints, always bearing in mind, of course, the maximum degree of angularity permissible for the joint in question.

Taking into account the limitations imposed by bearing life, as distinct from bearing strength, some manufacturers prefer to rate the torque capacities of their joints in terms of their expected use. Thus, a joint which may have a torque of 18,000 lb-in. in a static test may be given a torque rating of 10,000 lb-in. for intermittent use, and only 2200 lb-in. for continuous operation.

The torque capacity of joints also depends greatly on rotational speed. In some cases, only the maximum speed is specified at which the torque-capacity figures given by the manufacturer are valid. In other cases, a continuous dependence of capacity on speed is plotted. Thus, The Gear Grinding Machine Company, of Detroit, the original manufacturers of the Rzeppa joint, imposed a speed limitation depending on the operating angle, this limitation being so severe that, with an angularity of 16 deg., the permissible speed drops by as much as 90%. This, however, is a particular feature of the joint in question and does not apply to the needle-bearing Hooke's joint or the Chobham joint.

If, for simplicity of argument, consideration is first given to the constant-velocity joint, where the configuration of forces does not change with the rotation of the shafts, it is possible to represent the torque in each shaft by a vector which thus remains constant in time. Taking one of the shafts and replacing its physical contacts by forces, it can be seen that two torque or moment vectors act on this shaft, and these are not in line, so that they require a further moment vector to close the equilibrium diagram. This closing vector is at right angles to the axis of the shaft under consideration and therefore represents a bending moment which must be resisted by the reaction of the shaft supports.

If, instead of the constant-velocity joint, consideration if now given to a Hooke's joint, fluctuating torque vectors, and hence an equally fluctuating bending-moment vector, will be obtained. Fluctuations in both torque and bending moments occur twice per shaft revolution. This observation is particularly important in practice with regard to bending-moment fluctuations. Considering, for example, the intermediate shaft in layouts such as those in Fig. 15, this shaft receives an excitation twice per revolution. In designing a shaft, it is necessary to ensure against running at its critical speeds. The ordinary critical speed is one at which an excitation due to an unbalance, i.e., an excitation once per revolution, does not coincide with the natural frequency of the shaft in bending. It is clear that the intermediate shaft between two Hooke's joints must be so designed that its natural frequency in bending does not coincide with an excitation twice per revolution, as well as once per revolution. This situation does not often receive its proper attention.

Among dynamic forces, those due to the centrifugal force acting on elements on the joint itself must also be considered. Clearly, all the elements remain fully balanced in a Hooke's joint, but this is not necessarily true in every design of constant-velocity joint. For

example, an examination of the geometry of the Bendix-Weiss joint shows that its method of constraining the ball to remain in the bisecting plane causes this ball to move away from the centre, whilst the opposite ball moves towards the centre, thus creating an unbalance. On the other hand, in the Rzeppa or Birfield type of joint, all the balls are contained in a cage and are so constrained as to remain within a sphere concentric with the joint centre, thus preserving a perfect balance.

The forces developed in a joint have an effect on its efficiency. Friction losses occur as a result of frictional work and power loss, since a proportion of the power transmitted depends on the friction work per revolution. The friction work per revolution is a product of the tangential force (proportional to the torque divided by the effective diameter) of the friction coefficient and of the distance traversed by the points of contact, this distance being proportional to the angle between the shafts and to the effective diameter of the joint. In short, the effective diameter cancels out, and the torque is itself proportional to the energy transmitted per revolution. Consequently, the efficiency of the joint depends solely on the coefficient of friction and on the angle between the shafts.

However, the coefficient of friction is by no means constant even for any one type of sliding or rolling friction, but is greatly dependent on the specific pressure, the speed, and the design of the contact surfaces. This is particularly true in the case of rolling friction. For this reason, the size of the joint for a given torque has, in fact, a material influence on its efficiency, particularly in constant-velocity joints of the Bendix-Weiss or Rzeppa types, where a combination of rolling and sliding motions occurs.

Joints designed specifically for high efficiency are the Hardy Spicer and the Bendix-Weiss and Rzeppa joints. It is claimed that the Garringtons joint, although relying solely on sliding friction, has an efficiency of the same order, all these joints possessing an efficiency of 98% or higher at shaft angles of about 10 deg. The simple assumptions stated earlier suggest a linear dependence of efficiency on angularity, but the more complex considerations involved usually lead to a steeper, non-linear rise.

Lubrication

Like all mechanisms with sliding or rolling contacts, universal joints require lubrication. The typical automotive universal joint has grease-packed needle bearings, while the simple Hooke's joint for machine tools usually has pins and bearings lubricated by grease nipples. Most constant-velocity joints are either grease-lubricated or can be arranged to run in an oil bath.

The rules which govern the method of lubrication of these joints are roughly the same as those in rolling bearings, an important criterion being the linear velocity of the contact surfaces in their relative motion. In a universal joint, this linear velocity depends on the speed of rotation, the size of the joint, and the angle between the shafts. The detail design has an important effect, and the exact influences are too complex for easy generalizations. It may, however, be said that, where the efficiency of the joint falls below the point at which the friction losses converted into heat can be dissipated by the air during rotation, oil-bath lubrication becomes essential to help the removal of heat.

Like other precision assemblies with exposed surfaces, the proper operation and surface life of a universal joint are greatly improved by effective protection of the contact surfaces. Protection is achieved by the use of an external hose or bellows of accordion-pleated shape, by cork or other non-metallic seals, or by surrounding the joint with a housing, usually in association with an oil-bath. Incidentally, one Hardy Spicer joint, used in a British motor car, incorporates a new design of pre-packed bearing with an improved seal, retaining its initial charge of lubricant throughout its service life.

Acknowledgements

In the preparation of this survey, the co-operation of the following firms is gratefully acknowledged:—

BENDIX AVIATION CORPORATION, Bendix Products Division, South Bend, Ind., U.S.A.

BORG-WARNER CORPORATION, Mechanics Universal-Joint Division, 2026 Harrison Avenue, Rockford, Ill., U.S.A.

THE B.R.D. CO., LTD., Dumblederry Lane, Aldridge, Staffs.

HANS BÜHLER & CO., Wernau (Neckar), bei Stuttgart, Germany.

DANA CORPORATION, Con-Vel Division, 3901 Christopher Street, Detroit, Michigan, U.S.A.

DANA CORPORATION, Spicer Manufacturing Division, 4100 Bennett Road, Toledo 1, Ohio, U.S.A.

GIRLING LTD., Kings Road, Tyseley, Birmingham 11.

GLAENZER SPICER, 10 Rue J. P. Timbaud, Poissy (S. & O.), France.

HARDY, SPICER LIMITED, Chester Road, Erdington, Birmingham 24.

ETABLISSEMENTS HORSTMANN, 54 Rue Saint-Maur, Paris XI, France.

LUDW. LOEWE & CO., Huttenstrasse 17–20, Berlin NW 87, Germany.

METADUCTS LIMITED, Catherine Wheel Road, Brentford, Middlesex.

THE MOLLART ENGINEERING CO., LTD., Kingston By-Pass, Surbiton, Surrey.

THE MOSS GEAR CO., LTD., Universal Joint Division, Crown Works, Tyburn, Birmingham 24.

THE MOTOR GEAR & ENGINEERING CO., LTD., Chadwell Heath, Essex.

STANDAGE POWER COUPLINGS LTD., Telscombe Cliffs, Newhaven, Sussex.

JEAN WALTERSCHEID, Siegburg/Rhld., Germany.

FLEXIBLE COUPLINGS

When applied to couplings the resilience of rubber permits misalignment, absorbs torsional vibration, reduces noise in the transmission system and smooths out torque irregularities.

Full use of the properties of rubber is made possible by the Metalastik rubber-to-metal weld and to meet the problems associated with power transmission Metalastik has developed a family of flexible couplings. The rubber-to-metal weld is common to every member of the family but the designs, which emphasise one or another characteristic, vary widely so that a suitable coupling is available for any set of conditions.

The Trailing Link Coupling (Fig. 1) has been developed to accommodate an exceptional amount of parallel misalignment without power loss. Permitting angular misalignment and end float it is manufactured in a range of sizes to transmit 1–20 h.p. at 100 r.p.m. A single Trailing Link coupling will replace a long cardan shaft assembly.

The Double Cone type (Figs. 2 & 3) is very flexible torsionally to eliminate torsional vibration and absorb shock loads. It transmits thrust and is available for drives of 10 to 140 h.p. at 100 r.p.m.

Universal Couplings (Fig. 4) accommodate a large amount of angular misalignment with very low resistance. In sizes to transmit 0·3–3 h.p. at 100 r.p.m.

Specially designed for marine drives but suitable for other applications the Bicone coupling (Fig. 5) transmits thrust, absorbs torsional vibration and accommodates misalignment. Available for drives of 5–10 h.p. at 100 r.p.m.

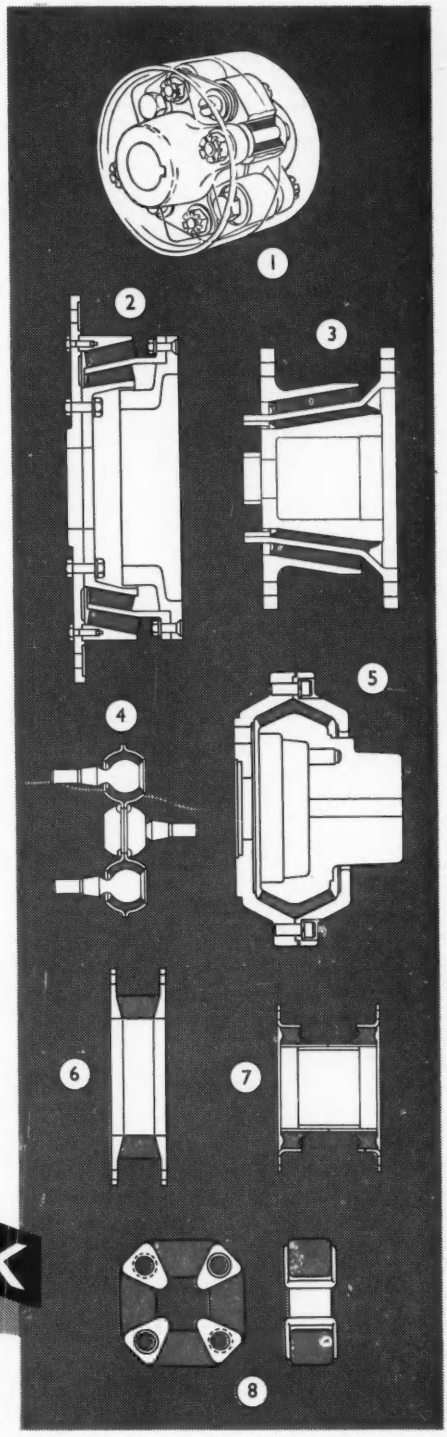
In various designs to transmit from a fraction of one horse power to 4 h.p. at 100 r.p.m. the Metalastik Vee-Type coupling (Fig. 6) has high torsional flexibility to absorb shock and damp vibration. A useful amount of misalignment is accommodated.

Fig. 7 shows two Metalastik Ultra-Duty bush couplings connected by a short shaft. This arrangement permits a high degree of torsional flexibility and provides for shock loads, torsional vibration and angular misalignment. For most applications in which the design can be employed to advantage, a single coupling is sufficient. Ultra-Duty bush couplings are available in sizes to transmit 0·75–18 h.p. at 100 r.p.m.

As much as 22° angular misalignment can be accommodated by the coupling of the Rotoflex type shown in Fig. 8 (plan and section). This coupling is fitted in the steering column of production motor cars and is valuable for many other applications in which a large degree of universal movement with shock absorption is required. Rotoflex couplings are available to transmit 5·5–42 h.p. at 100 r.p.m.

Metalastik couplings, in conjunction with Metalastik flexible bearings and anti-vibration mountings, give sweeter, vibration-free running and eliminate lubrication.

Our experience is at your disposal.



METALASTIK

METALASTIK LTD., LEICESTER

STRATELINE SPEED REDUCERS

- This Strateline unit has an output capacity of 7,000 lb. i required by maximum out of balance conditions whil working on the Engine.
- The ratio illustrated is 60:1, but ratios between 20:1 and 100:1 are provided by the hypocycloidal gearing.
- Self-sustaining Strateline mechanism which operates when movement of input handle ceases—the engine can be rotated, and sustained at any position, through 360°.

The photograph above shows the type CW1 Strateline unit fitted to a Rolls-Royce Dart Aero Engine Overhaul Stand designed and manufactured by Messrs. Morfax Limited of Mitcham, Surrey. The high efficiency and compact assembly of the Strateline makes it particularly suitable for manual operation and many variations have been supplied for high pressure valve operation, hand winch units, furnace tilting, etc. Where reasonable quantities are involved we are prepared to design special units against particular applications

VARATIO-STRATELINE GEARS LTD.

277/9 ABERDEEN AVENUE,

TRADING ESTATE, SLOUGH, BUCKS.

TO ACCOMMODATE SHAFT MISALIGNMENT

THE METASTREAM CN SERIES

ALL METALLIC

NON LUBRICATED

LOW PRICED

Double Membrane Bank for parallel misalignment.
Single Membrane Bank (illustrated) for angular misalignment.
From $1\frac{7}{8}$ in. diameter for 2 HP per 1000 rpm at 15s. 6d.
To $4\frac{1}{2}$ in. diameter for 10 HP per 1000 rpm.
Higher powers up to 8000 HP per 1000 rpm accommodated on

THE METASTREAM M SERIES

Write for literature today

METADUCTS LIMITED, CATHERINE WHEEL ROAD, BRENTFORD, MIDDLESEX

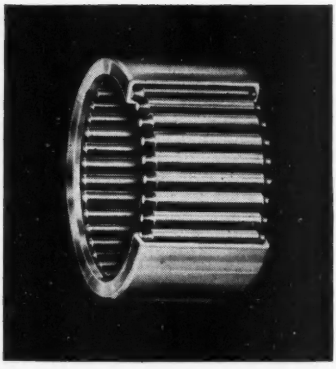
A Member of the Concentric Group of Companies.

TRIUMPH

B59/E

with

TORRINGTON



The TRIUMPH Herald is justly described as "a new experience in motoring", having among other novel and attractive features independent suspension on all four wheels. TORRINGTON Needle Bearings feature in the drive-shafts and also in the already established gearbox application. Compactness and light weight combined with unequalled capacity and low starting and running friction at low cost make TORRINGTON Needle Bearings vital for efficient and economic design.

TORRINGTON BEARINGS

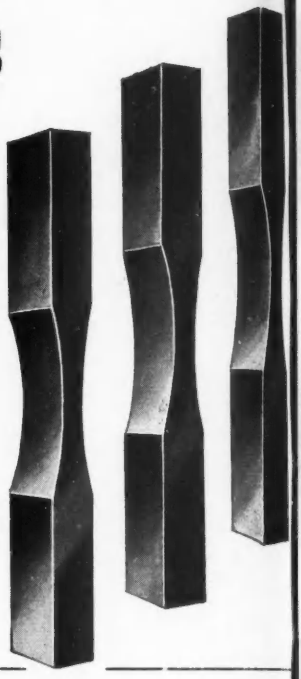
The Torrington Company Ltd. Bearings Division Torrington Avenue Coventry
London & Export Office: 7-10 Eldon Street, E.C.2.

Glasgow Office:
50 Wellington Street, C.2

Individual Springs

give real flexibility to couplings

Serious misalignment between two units . . . extreme emergency conditions. No need to worry when the Steel-Shaw Coupling provides the link. Flexibility will be retained—INDIVIDUAL SPRINGS (instead of the usual coil) means that although there is no direct, heavy shear, there will be no break at the coupling. The resistance of these springs in this unique unit is enormous—approximately fifteen times the heaviest working load. Write for full details to-day.



STEEL-SHAW

Head Office:
STEELE & COWLISHAW LTD.,
Cooper St. Hanley, Stoke-on-Trent.
Tel: Stoke 23333 (5 lines) Telex 3630.

London Office: Kingsway House, 103 Kingsway, London, W.C.2.
Tel: HOLborn 8225.

Overseas Sales: Baker Perkins (Exports) Ltd.,
Westwood House, Swallow Street, Piccadilly, W.1.
Tel: REGent 8301.

A MEMBER OF THE BAKER PERKINS GROUP

Solve your power transmission problem

IT

REDUCES
The peak amperage during starting

ELIMINATES
Starting shock and snatch

PREVENTS
Overloading electric motors and burning them out
Breakage of fragile materials due to sudden starting shock.
Damage due to overload.

INCREASES
The life of belt and gearing

PERMITS
Inching and rapid reversal.

SAVES
The cost of high starting torque motors.

RELIEVES
The motor of load.

with the amazing

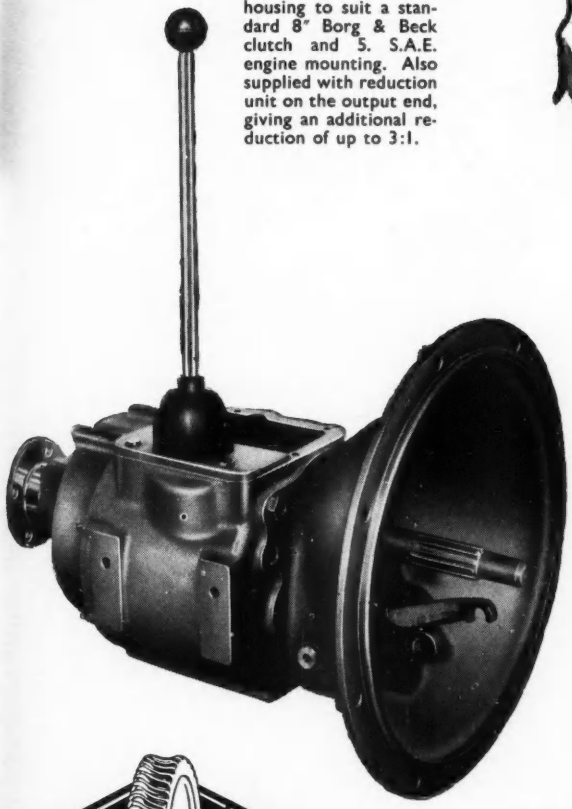
DRY FLUID CENTRIFUGAL COUPLING

For technical information and assistance write to . . .

POWDER COUPLINGS LTD.,
A Member of the Specialloid Group of Companies
20 BLACK BULL STREET, LEEDS, 10
Telephone: LEEDS 20936 & 31471/7

ECONOMY WITH RELIABILITY

The 40M. Three speed and reverse, constant mesh unit is capable of accepting up to 60 lbs/feet. Extremely robust, for very arduous conditions; suitable for dumpers, tractors, towing tugs, etc., where long periods of running in the indirect gears are required. Supplied with or without bell-housing to suit a standard 8" Borg & Beck clutch and S. S.A.E. engine mounting. Also supplied with reduction unit on the output end, giving an additional reduction of up to 3:1.



Have you seen our standard MOTOR IN WHEEL which gives a reduction of up to 30 : 1 in a single compact unit.?

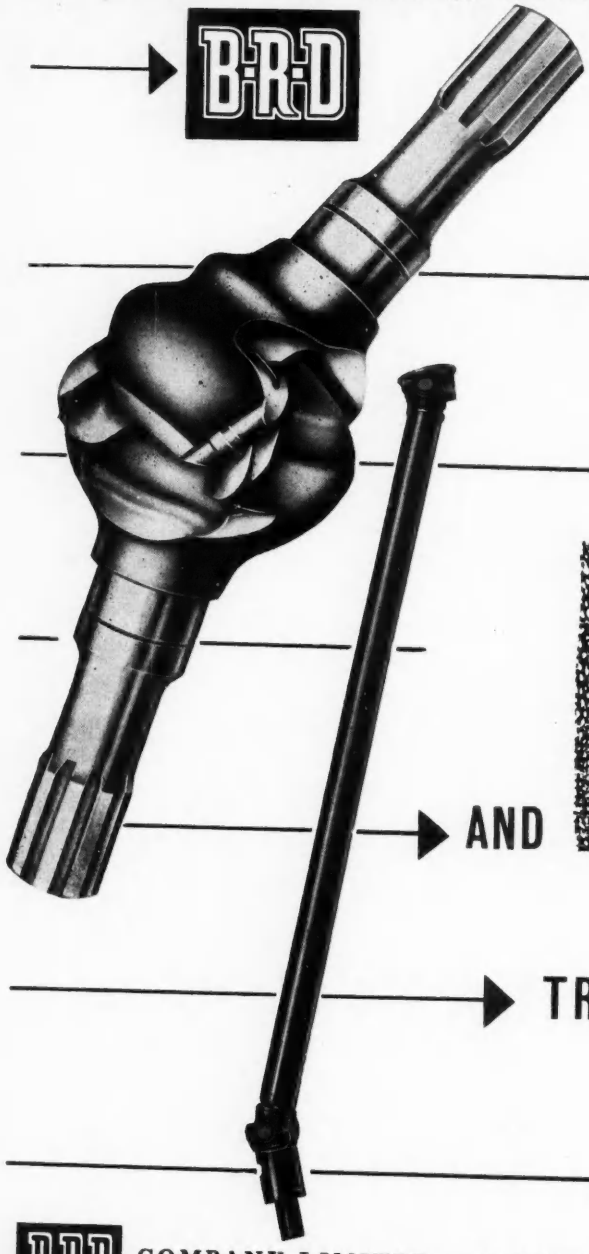
P. R. MOTORS LTD.

ALDBOURNE ROAD, COVENTRY

Telephone: 22266/7. Telegrams: Supagears, Coventry.

SPECIALISTS IN VEHICLE GEAR BOXES SINCE 1902

B·R·D



UNIVERSAL

JOINTS

Original suppliers of transmission equipment to the Motor industry

AND

TRANSMISSION

SHAFTS

B·R·D COMPANY LIMITED · ALDRIDGE · STAFFS · ENGLAND

A Member of the G.K.N. Group of Companies

THE ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XX No. 12 DECEMBER, 1959

Moving with the Times

FOR close on twenty years, this journal has been publishing information on the latest developments in world engineering. We have much to impart, and we hope we impart it well.

All the same, we are only too well aware that each of our readers has his own particular pet subjects, and what may be of intense interest to him may well be anything but interesting to others, and vice versa.

It occurred to us, therefore, to ask a number of very old friends of ours—some of our oldest readers and bluntest critics—what they really thought of our editorial content, by and large. To our surprise, they replied that (quite apart from the subjects they were themselves interested in and about which they expressed their rather flattering approval), they found it, well, "dignified but dull".

Now, we were naturally rather pleased with the "dignified" part of the criticism, until we remembered that a combination of dignity and dullness is only too often synonymous with being a crashing bore. On the other hand, if dullness is sometimes a necessary concomitant of seriousness, then dullness seems to us to be inevitable in any truly serious technical journal. It is difficult to see how it can be otherwise, and we imagine the same criticism must often be levelled at other journals of the same calibre as ours.

Perhaps, we thought, a solution to the problem might lie in the so-called popular approach of splashing around lots of whimsical colour-schemes, coupled with variegated type-faces and the use of "fancy" captions of the kind found in some American technical journals. You know, something like this :—

New Hotshot Alloy is High-Temp Toughie

or this:—

Superduper Socko Technique Puts Zing in Zirconium

However, when we tackled our friends again about this idea, they were frankly horrified.

"Good gracious!" they exclaimed, "you can't do that. It wouldn't be *dignified*, and a serious journal *must* be dignified."

"In fact," they added, with a conscious dignity of their own, engendered no doubt by an expensive classical education, "dignity is a *sine qua non*".

To which, not to be out-tagged, we courteously replied "*Quot homines, tot sententiae*", and nearly broke up a beautiful friendship.

But it is quite true, for all that:—Opinions do differ. As we have already said, we have been publishing this journal for nearly twenty years, and perhaps most of our readers like it just as it is. Even so, we would like to move with the times, but fear to do something which would be greeted with the same stunned distaste as would be occasioned if, for instance, *The Times*, that admirably sturdy bulwark of unassailable dignity, suddenly included a regular selection of cheese-cake photographs from *The Daily Mirror*.

If our critics are right, how can we solve our problem? Apparently, if we remain serious, we must be dull; if we are not serious, we must be undignified. Are we, then, to sacrifice dullness and dignity at the shrine of popular appeal, or are we to remain sternly aloof and preserve the even tenor of our way? In short, are we to move with the times, or are we to move with *The Times*?

It is all very perplexing.

And now let us confess that we have long had a secret yearning to publish something that is not serious, dull, dignified (call it what you will). Because it is Christmas, then, we have just this once let our editorial hair down, with the results you will see on pages 494 and 495. It's all sheer nonsense, of course—extravagant, gloriously extravagant, nonsense—but if you get half as much fun reading it as we have had producing it, what more can we ask?

Of course, we may be sticking our necks out, and frankly it wouldn't surprise us a bit if we get this criticism:—"We found your highly technical article on the Ministry's Kettle most instructive and dignified, though somewhat dull. Your humorous survey of Universal Joints was extremely amusing."

Maybe, though, a little nonsense now and then is the real answer to our problem.

Also, for good measure, we have included on pages 511 and 512 our Prize Competitions—another innovation for us—and we hope you will compete. Whether we continue with these competitions naturally depends entirely on your response.

Finally, may we conclude with a message which may be trite, but is always dignified and certainly never dull,

A Merry Christmas

and

A Happy New Year

The Singular Affair of the Ministry's Kettle

By LICEC DRAZEL. (From *Epics of Efficiency or Now it can be Told;* published by Chitman and Pall, Blackie Street, McGraw Hill, London, 1959)

Editorial Note:—The pseudonym "Licec Drazel" hides the identity of one of the best-known members of the British Secret Service. In this extract from his famous book, he reproduces a typical Progress Report from the archives of some of that gallant band of scientists who, unknown to the public and without thought of reward, have, by their courage, their selfless interest in pure research, and their single-minded tenacity of purpose, done so much to epitomize the Bulldog Breed. Gripping in its intensity, poignant in its simplicity, this Dramatic Documentary of Devotion to Duty is not only grippingly poignant, but may even be said to be poignantly gripping.

February 3, 1959:—Scientific work at Barwell has been seriously hampered of late by the insistent demands of the Ministry of Atomic Research for more intensive security screening of personnel. This demand appears unreasonable, as our security measures are already nearly perfect. However, even stricter attention is now being given to this matter.

February 6th:—The most stringent security measures are now being enforced. All existing personnel have been rigidly screened, including our new Welsh assistant bottle-washer, Dmitri Sergei Ivanovich Evans, who apparently comes from the little mining village of Lladivllostock. The Centre is therefore now free to devote all its energy to Research Project No. 783, which is concerned with the problem of the electric kettle received a few days ago from the Ministry with a request that it be examined to find out why it is no longer capable of boiling water. No information regarding this extraordinary phenomenon has been vouchsafed, other than the statement from Sir Jollibutt Dangle, Director of Research at Barwell, who states:—"With reference to the Singular Affair of the Ministry's Kettle, I have made a personal examination and must confess that I am Utterly Baffled."

February 9th:—The services of all personnel have been enlisted in this investigation, so far without result. However, Dmitri has interested himself in the problem, and Dmitri's ideas are worth hearing. It is known that he has a string of scientific degrees, so why he should be content to take a post as assistant bottle-washer is in itself something of a mystery.

February 16th:—Dmitri has examined the kettle and states categorically in his charming Welsh lilt:—

> "To this problem the solution ridiculously simple is:—The kettle cannot water boil because, after inspection of great detail, no water in it I am finding."

Preliminary investigations have disproved this ingenious theory completely. On filling the kettle with water, its temperature rose only 2°C in one hour. This was subsequently discovered to be due to the fact that the day was steadily growing hotter.

Research on this fascinating problem is proceeding.

March 3rd:—A more detailed examination of the kettle by Dr. B. Terèse, of Isotopes, reveals the following important points:—

(a) After subjection to neutron bombardment in the reactor for three hours, the kettle showed signs of radioactivity.
(b) When turned upside down, the chromium-plated lid of the kettle could be used as an ashtray.
(c) The kettle was not plugged into the power-socket.

Accordingly, chemical analysis of the chromium-plating is being undertaken.

March 10th:—Analysis of the chromium-plating has been completed and clearly establishes that the chromium is mainly composed of chromium.

This analysis, coupled with the fact that no heat was developed when the kettle was plugged into the socket, is felt to be significant, and investigations are proceeding.

March 27th:—Dmitri has propounded a new theory to account for the defect in the kettle:—It appears that the Third Secretary to the Minister was accustomed, after plugging in the kettle, to watch it carefully, to check whether it was working properly. It is felt that this procedure is highly irregular, and the Ministry of Atomic Research has been signalled for details of the behaviour of their kettles in such circumstances.

April 7th:—A reply has been received from the Ministry, as follows:—

> *Ref.: Kettles, Electric:*—UNDERSTAND ON GOOD AUTHORITY THAT A WATCHED POT NEVER BOILS (.) DO NOT CONSIDER THERE IS ANY IMPORTANT DIFFERENCE BETWEEN A POT AND KETTLE ESPECIALLY IF BOTH ARE BLACK (.) SUGGEST YOU CONDUCT TESTS TO VERIFY THIS THEORY UNDER LOCAL CONDITIONS (.) GOOD LUCK IN THIS EPOCH-MAKING RESEARCH WHICH MUST BE CLASSED TOP-SECRET (.)

April 28th:—Experiments conclusively prove that, under local conditions, the theory that a watched pot never boils (Boyle's Law) is probably false.

Several pots and kettles of assorted colours were filled with water and heated gently under uniform conditions. It was found that, on an average, an unwatched pot (or kettle) boiled in 33·4 minutes, while a watched kettle (or pot) boiled in 33·6 minutes.

It is considered that this difference is negligible, and investigation of the problem must therefore be conducted on different lines.

May 17th:—Results have so far proved negative, despite unflagging efforts.

The kettle was exposed to an ultraviolet-ray lamp for 17 minutes, and infrared photographs were taken of the bakelite handle by Dmitri with his special miniature camera (he is an expert photographer, by the way). The kettle, however, still does not boil water, and new lines of research are under way.

June 12th:—On opening up the base of the kettle, a mass of wire, wrapped around a sheet of mica, was accidentally discovered. The heads of all Departments have been called in to give their views on the possible reasons for its presence. Thus, the eminent French savant, Count de Clyx (Radiation Detectors) believes the wire to be a built-in vibration damper, while Dr. Rodin Tackle (Nuclear Fission) insists it is a new type of dust-collector. On the other hand, Dr. Emma Royde (Atomic Piles) asserts it to be some form of radio suppressor, but Dimitri, who is a keen radio amateur and keeps a short-wave transmitter in his bedroom (really, there is no end

to the versatility of the fellow!) says this is absurd and inclines to the frankly extravagant belief that the wire could be some form of heating element.

Microscopic and spectroscopic examination of the wire is under way.

June 30th:—Photomicrographs of a section of the wire reveal a uniformly white and extremely bright surface, as shown in Fig. 1. This was found to be due to the presence of a layer of monoxide of molybdenum (OMo), which is known to confer added brightness.

Fig. 1. **Photomicrograph (× 30) of a section of the wire, showing surface brightness produced by OMo.**

Spectroscopic analysis clearly shows the presence of some unknown element or other. However, when this element was subjected to a temperature of 345°C, it became noticeably hot. It is therefore concluded that the element is definitely a heating element.

July 7th:—Detailed examination of the wire discloses the following important considerations:—

(a) The wire (Fig. 2a) is completely odourless and tasteless.
(b) A small piece of the wire, when used as a gramophone needle, was found to be utterly useless.
(c) The wire is broken in four places (Fig. 2b).

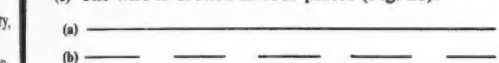


Fig. 2. **Photographs of wire (natural size), showing (a) portion of unbroken wire, and (b) the broken portion.**

From the above, it is considered possible that the cause of the trouble may well lie in the heating element. Experiments are continuing.

July 17th:—A suggestion has been received from Professor Nimbus Potts (Cloud-Chambers) to the effect that the problem can easily be solved by mounting the kettle on a suitable stand and boiling the water by means of a Primus stove placed beneath it. This suggestion is highly ingenious but unethical, and has rightly been condemned as unworthy of the Finer Ideals of the Centre. As a result, Professor Potts has been Severely Reprimanded and publicly deprived of his Geiger Counter.

The Director is rightly determined that the problem must be solved scientifically or not at all, and further experiments are being initiated.

August 10th:—It has now been definitely established that the trouble is caused by a defective heating element.

A new element was prepared and tried out. Unfortunately, the kettle stopped heating after two minutes. Dmitri believes that the Electric Light Company are to blame for this failure, and arrangements are accordingly being made to install a new generator in Barwell Town power station.

October 20th:—The new generator in Barwell power station has been installed, but the kettle still does not boil water. Examination by Professor Plötzen, of Plutonium Power Plants, reveals the following significant items:—

(a) When subjected to the action of a radioactive isotope of banana ($BaNa_2$), the kettle was found to be comparatively useless in the treatment of sciatica.
(b) When a magnet was brought near to the surface of the lid of the kettle, it was totally unable to light a cigarette.
(c) The wire of the new heating element is broken in eighteen places.

In the circumstances, it is felt that a new heating element should be installed.

October 27th:—A second heating element has been installed, and burned out in three minutes.

November 3rd:—A third heating element has been installed, and burned out in four minutes.

November 8th:—A fourth heating element has been installed, and burned out in five minutes. It is felt that success is just around the corner.

November 19th:—A fifth heating element has been installed, and burned out in three seconds.

December 15th:—The problem has now been SUCCESSFULLY SOLVED, thanks to a brilliant suggestion from Dmitri. The Ministry reports that its kettle now regularly boils a quart of cold water in six minutes, as often as desired, and shows no signs of burning out.

As a result, the Ministry has sent the Centre its heartiest congratulations on the successful outcome of one of the most difficult research problems it has ever had to tackle, and has been pleased to sanction the Expenditure Sheet, as follows:—

EXPENDITURE SHEET — RESEARCH PROJECT NO. 783

Purchase of new generator for Barwell power station	£75,390	0	0
12¼ miles of resistance wire for various heating elements	£1,134	9	0
Neutron bombardment of kettle for 3 hours	£630	18	9
Purchase of new electric kettle	£2	1	6
Total	£77,157	9	3

As a result of his outstanding intervention, Dmitri has been promoted and has been appointed to an administrative post as Custodian of the Barwell Secret-Files Department.

Self-Regenerating Botanical Battery

A revolutionary new discovery is announced by the distinguished Eastern philosopher, Khan Hari Singh, who states that, if a fully grown specimen of the rare Indian *multispinus* cactus is allowed to stand in a jar of electrocactic acid, a virtually inexhaustible supply of electric current is generated. Each pair of spines of the cactus forms an alternate positive and negative electrode, so that various combinations in series and parallel can be arranged to produce different voltages. In fact, it is estimated that the voltage of a single charged *multispinus* battery can be adjusted between 6 and 600 V, with a maximum power output of 7 kVA.

A special feature of the battery is that it is self-regenerative, as it actually produces electrocactic acid during its discharge, thus replenishing the contents of the jar and thereby recharging itself. Also, once a year it flowers, producing seeds which rapidly develop into large numbers of additional fully charged batteries.

According to the inventor, the one minor drawback so far noted is the fact that the only known method of producing electrocactic acid is by discharging a *multispinus* cactus which has first been charged by standing it in a jar of electrocactic acid.

SWITZERLAND

Methods of Measuring the Speed, Acceleration, and Torque of Moving Parts

By H. RENKER. (From *Schweizer Archiv*, October 1959, pp. 381–384, 6 illustrations)

MEASUREMENTS of the speed and acceleration of rotating parts can be obtained fairly simply with a tacho-generator, which gives an output voltage proportional to angular velocity. In some cases, a tacho-generator can also be used for linear measurements (e.g., of the table of a planing machine), but the method of connecting up the generator to produce its rotary motion may require considerable preparatory work. Moreover, the response of a tacho-generator may not be rapid enough for high-speed movements to be indicated without distortion.

A common feature of most conventional methods is that they require the fitting of an electromechanical transducer to the moving part, and this may not always be easy. Furthermore, as the transducer can in some instances appreciably alter the mass of the part under test, the results may contain a large percentage error.

These difficulties can be avoided by using one of the following relatively simple methods, all of which eliminate the drawback of loading the moving part with a comparatively heavy additional mass. In these methods, the part under test is provided with regularly spaced mechanical, magnetic-tape, or optical scale divisions, these divisions being sensed by a stationary pick-up element and converted into electrical pulses which can be amplified. The pulse intervals are directly proportional to speed, and any change in these intervals is directly proportional to acceleration. Consequently, both speed and acceleration can be recorded, either on a chart or on an oscilloscope.

In the mechanical method, which is particularly suitable for measurements on rotating parts, the signal generator can be a toothed disc, the passage of each tooth over the measuring position being sensed by a magnetic pick-up, in which the current pulses are induced proportionately to the change in flux.

In the magnetic-tape method, the scale divisions can be impressed on a magnetic tape by means of constant-frequency signals from an oscillator. The tape is then mounted with a suitable adhesive on the part to be tested, and measurements are obtained by a play-back head which produces corresponding electrical pulses.

In the optical method, use is made of a paper tape regularly inscribed with black lines on a white background. The paper is then glued to the part under investigation, and the markings are scanned by a photocell and converted into electrical pulses.

Both the magnetic and optical methods are particularly useful in cases where the moment of inertia of the moving part has to be kept unchanged, or where measurements must be taken rapidly without extensive preparations.

As an example of the use of the mechanical method, tests were carried out to determine the operating characteristics of a clutch used in conjunction with a two-speed gearbox and driven by a 75-hp electric motor. In this case, the input and output shafts were each provided with a toothed disc having 104 teeth, so that, at a speed of, say, 1000 rpm, the pulses from the magnetic pick-up had a frequency of about 1700 cps. These pulses were then amplified and passed through an integrating unit, the resulting voltages being fed to a pen recorder, giving two traces with amplitudes proportional to speed. Using a recording-paper speed of 100 mm/sec, the results were easily readable for time intervals as short as 5 milliseconds, and satisfactory and unsatisfactory clutch operation was plainly visible (Fig. 1), enabling the necessary adjustments to the clutch to be made.

In another application, in this case involving the use of the magnetic-tape method, investigations were made into torsional vibrations of the drive spindle of a copying lathe. As these vibrations were caused by relative movements between the tool and workpiece at fairly high frequencies, it was necessary to provide a higher degree of resolution than that obtainable with a toothed disc. For this reason, the magnetic-tape method was chosen, the tape being glued directly around the chuck. With 732 recorded impulses on the tape, the impulse frequency obtained at a speed of 930 rpm was about 11,200 cps, enabling vibration amplitudes of as low as 0·5 deg. to be determined. This degree of resolution was fully adequate to identify the fundamental vibration at a fairly high frequency, and also its harmonics.

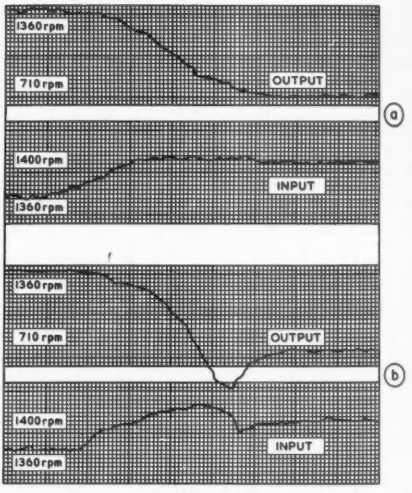


Fig. 1. Recordings obtained with the mechanical method for testing clutch operation during gear changes, showing (a) satisfactory clutch operation, and (b) unsatisfactory clutch operation.

In addition to measuring the speed and acceleration of moving parts, the optical method is also suitable for measurements of shaft torque. For this purpose, a part of the shaft with a fair amount of torsional flexibility is chosen, and each end is fitted with a graduated paper strip glued around its periphery. With fine and closely spaced lines, pulse frequencies up to 10,000 cps can be obtained. Each strip is scanned by a photo-cell, with a slotted mask for adjustment to the correct strip width, and the photocell output signals are fed to a two-channel measuring bridge. Measurement of torque is obtained from the distance between successive pulse peaks of the two signals received, the final output being integrated and measured as a d.c. voltage. For evaluation, a preliminary calibration of the output voltage in terms of torque is, of course, necessary. A third trace, giving instantaneous variations in torque, can then also be registered directly by the recording equipment.

The Machining of Reactor Materials

By A. O. Schmidt,* B. L. Richardson,† and J. R. Roubik.‡

Many standard engineering materials are used in reactor construction, and some of these have been given specific properties or have been alloyed for service conditions peculiar to reactors. Others, like stainless steel and titanium alloys, which are widely employed in reactor construction, have been dealt with extensively elsewhere. However, several new materials have been developed for use in reactors, among them being cladding materials for fuel elements and shielding materials, and this report is concerned with the machining properties of the latter types of materials, as well as with the machining of uranium. In addition, consideration is given to the problems of toxicity and radiation associated with the fabrication of these materials.

ZIRCALOY-2

Among the newer engineering materials are zirconium alloys. Of these, the neutron-capture characteristic for Zircaloy-2 is very low, and it is therefore used as a fuel-cladding material in nuclear power reactors. It is also employed instead of stainless steel in reactor structures. Because of their good mechanical strength, heat resistance, and outstanding corrosion resistance, zirconium alloys are used in chemical-processing equipment and can be expected to have a more general industrial application[1,2].

For cladding uranium fuel elements, Zircaloy-2 may be in tubular shapes or in the form of plates with recesses or pockets. Owing to the present high price of zirconium alloys, it is imperative to develop machining methods which will produce the required quality in dimensions and surfaces with maximum output and a minimum of scrap[3,4,5].

The material can be milled with carbide and high-speed-steel cutters. Large relief angles of approximately 10 deg. are effective in avoiding the tendency of the material to build up on the flanks of the tool and in eliminating the associated heavy burr on the workpiece, overheating, and sparking. Positive rake angles can be used to reduce the amount of heat in a thin workpiece and its tendency to deform, while adherence of the chip to the cutter can be prevented by spraying an emulsion on the workpiece surface before starting the cut. Sharp cutters with sufficient clearance angles, coarser feeds, and the elimination of chips from the table of the machine are the most effective means of minimizing the fire hazard.

The envelopes for fuel elements of atomic reactors must meet strict specifications regarding surface finish and cleanliness, dimensional accuracy, and straightness. Also, in the milling of recesses, sharp corners at the sides of the recess and blending of the radius generated by the cutter with the bottom flat surface at each end of the recess are definite machining requirements. As a protective container for the fuel element, a pair of such cover-plates is finally assembled under high pressure and elevated temperature, bonding being effected by diffusion and grain growth across the interface, which has been generated by a milling cutter[6].

Although zirconium is pyrophoric, difficulties on this account occur only in those machining operations which produce fine chips, such as sawing and finishing operations in milling, grinding, turning, and boring. This hazard can be overcome by flooding the tool and workpiece with an emulsion and by not permitting tools to dwell in a cut. The friction of a tool rubbing against a workpiece while not cutting can generate enough heat to ignite small chips.

In milling tests, it has been the experience of reactor manufacturers that machined parts of Zircaloy-2 are sometimes unsatisfactory because of a smeared metal residue left by the metal-cutting process, possibly as a consequence of chip crowding and a burnishing action of the tool, especially in confined areas. Since even hand operations often will not eliminate this condition, it is a prime requirement to design tools which stay sharp and cut clean. A cutting operation which causes heat and burrs can also produce oxidation to a considerable degree. In high-speed machining, for example, temperatures can be attained that are close to the melting point of the workpiece material.

Oxidation can occur in any machined material and is influenced by high temperatures near the cutting zone. The degree of oxidation of chips which are smeared against the freshly machined surface and of burrs on the workpiece is strongly affected by these temperatures. Normally, this action would not interfere with the subsequent usage of a workpiece, but it cannot be tolerated in reactor components coming into contact with fuel elements.

Because of the above requirements, it is necessary that an effective tool for the machining of Zircaloy-2 must have positive axial rake angles, especially for milling a pocket. An ordinary spiral slab mill has a negative axial rake angle at one side, by virtue of its single spiral configuration. Thus, to permit positive axial rake angles to be effective at both sides of a milling pocket or recess, it is essential to use a herringbone set of slab mills. If no Zircaloy-2 material is available for experimental cuts, exploratory tests regarding cutter design, surface finish, dimensional accuracy, clean cutting, and holding of the workpiece can be carried out with flat strips of SAE-1020 cold-rolled steel. These preliminary tests will give a valid indication of conditions to be encountered later, except for the influence of the relief angles, which must be increased to 10 deg. or more for machining Zircaloy-2.

Zircaloy-2 can be sawed on a bandsaw ordinarily used for steel. However, a combination of friction in the cut, lack of cutting fluid, and fine chips from the sawing operation can easily generate enough heat to ignite the chips. A copious supply of an emulsion and no idling of the saw in the cut serve effectively to prevent ignition. A dry-powder extinguisher of the type used for magnesium fires is also satisfactory for zirconium. Fire-extinguishers using carbon dioxide, carbon tetrachloride, or water should not be applied.

The milling of flat surfaces has been carried out successfully with carbide face mills having positive radial rake angles designed to permit ready change of the radial rake angle at the cutting edge[3]. The teeth were set into the cutter body at either a 15- or a 30-deg. positive radial rake angle, and a negative or different positive primary

* Chief Engineer, Metal Cutting Research, Kearney & Trecker Corporation, and Research Professor, Marquette University, Milwaukee, Wis.

† Assistant Professor and Chairman, Nuclear Engineering Committee, Marquette University, Milwaukee, Wis.

‡ Research Engineer, Kearney & Trecker Corporation, Milwaukee, Wis.

radial rake angle was superimposed on the cutting edge, as shown in Fig. 1. It was found that, irrespective of whether the primary rake angle was — 10 or + 10 deg., or any value in between, there was no appreciable effect on cutter performance, provided that the relief angle was approximately 10 deg. The large positive rake angle helped to reduce the power required in the cut, and also improved chip formation. A relief angle of 5 deg. caused excessive smearing, tool wear, and sparking after a very short cutting time, as shown in Fig. 2, whereas none of this trouble occurred when the relief angle was increased to 10 deg. To prevent chips from clinging to the cutter, a jet of compressed air, directed against the teeth as they left the cut, was found to be effective.

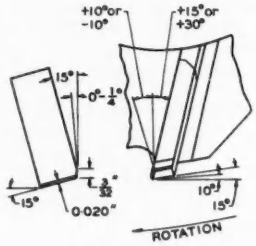


Fig. 1. Tool angles used in the face-milling of Zircaloy-2.

A total of 3000 sq in. of Zircaloy-2 was milled with a carbide cutter having eight teeth of a C-2 grade of carbide, using a cutting speed of 200 fpm, a depth of cut of 0·060 in., and a feed of 0·010 in. per tooth. At this point, the cutter did not show more than 0·010 in. peripheral wear. If the workpiece thickness exceeds 0·200 in., this amount of wear and the heat it can generate in cutting may not be objectionable. However, since the workpiece will absorb about 12% of the cutting energy with sharp cutters, this can easily increase when the cutting tools become even slightly dull. If the Zircaloy-2 workpiece is thin, this heat could cause considerable warpage and is therefore a factor which often requires a tool to be resharpened when the wear mark on the periphery has reached 0·005 in.[7,8]

From the values of nett energy requirements for sharp

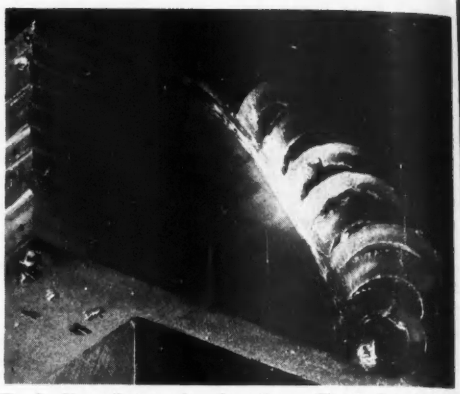


Fig. 2. Unusually heavy burr formation on Zircaloy-2 workpieces, when face-milling with a 5-deg. relief angle on the tool.

cutters in milling Zircaloy-2, obtained when face-milling a number of materials with different carbides and various rake and relief angles, it can be deduced that a relief angle of only 4 deg. requires slightly more energy for all the materials tested. An increase in energy requirements of about 15% can be ascribed to a change in the radial

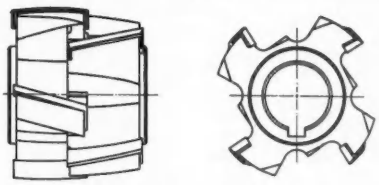


Fig. 3. Adjustable herringbone set of slab-milling cutters.

rake angle from + 4 deg. to — 7 deg. Although a relief angle of 4 deg. usually will work satisfactorily in steel, with continued cutting it will soon cause smearing in aluminium alloys, and smearing and sparking in Zircaloy-2. Of course, an increase in peripheral interference with growing flank wear will greatly increase energy and power requirements. In these tests, it was also found that the C-2 type of carbide showed more of a tendency towards peripheral interference than the C-50 type.

In slab-milling with high-speed-steel or carbide cutters, it was found advantageous to apply an ordinary water-soluble oil emulsion to the surface of the workpiece before starting the cut, thereby preventing the chips from being carried around by the cutter and smearing or marring the freshly machined surface. A recess was milled in a Zircaloy-2 cover-plate with an adjustable interlocking herringbone set of slab mills of the type shown in Fig. 3, in which the effective positive axial rake angles at the outer edges of the cutter set

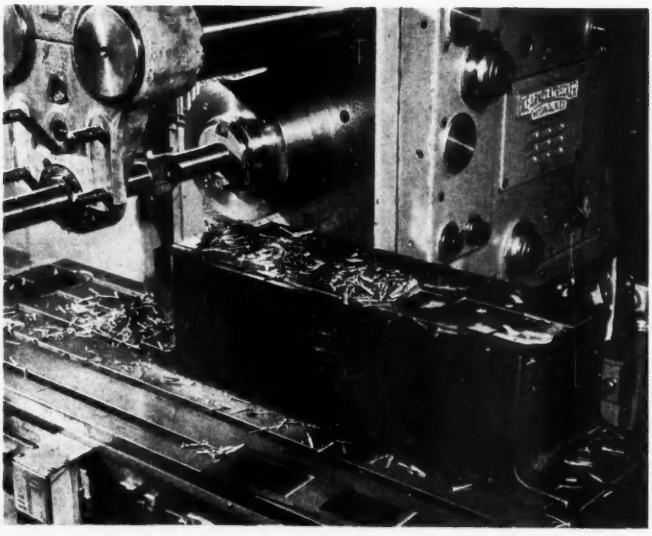


Fig. 4. Set-up of production milling machine for milling recesses in Zircaloy-2 cover-plates.

permit smear-free cutting at the sides of shallow slots or channels, using a production bed-type milling machine with an automatic cycle. The set-up with this machine is illustrated in Fig. 4, table feed being from right to left, with left-hand spindle rotation for climb-cutting. An emulsion was sprayed onto the workpiece prior to cutting. The main advantage of the automatic-cycle arrangement used is that it permits the recess to be milled without any significant dwell of the cutter at the entrance to and exit from the recess. A close-up view of the recess in the Zircaloy-2 cover-plate is shown in Fig. 5, which clearly indicates the freedom from metal smear obtained and the absence of burrs at the sides of the recess. The smooth blending of the end radius with the flat bottom of the recess (i.e., absence of cutter dwell marks) should also be noted. Besides eliminating possible human errors in repetition or work accuracy, the dimensional repeatability of the workpiece, using automatic cycling, was satisfactory with regard to the length and depth of each recess, and also with respect to the positions of the recesses relative to each other and to the end of the workpiece. From the point of view of adequately holding comparatively thin workpieces, it is advantageous to use climb-milling, rather than conventional milling, in slotting and stabbing cuts.

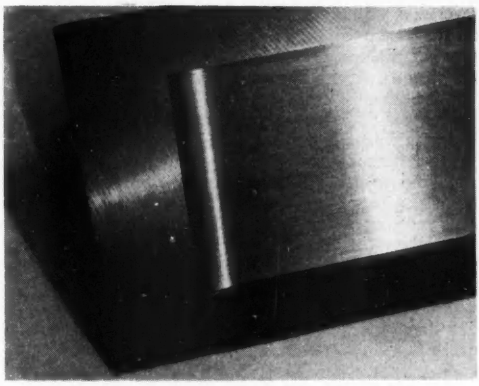


Fig. 5. Close-up of recess in Zircaloy-2 cover-plate.

ALUMINIUM X-8001

An aluminium-nickel alloy, designated X-8001, has been developed at the Argonne National Laboratory and is more corrosion-resistant in water at high temperatures than aluminium-iron alloys. This alloy does not seriously absorb or interfere with neutrons generated in the reactor, so that it can be used advantageously as a cladding material for fuel elements.

With aluminium X-8001, a good surface finish and cleanliness of cut can be maintained, as also can the dimensions and straightness of the workpiece, with tools that have been finished with diamond honing compounds to a 2-microinch r.m.s. surface finish.

MALLORY 1000

Mallory 1000, which is an alloy containing 90% tungsten, 6% nickel, and 4% copper, can be used as a shielding material against gamma rays and X-rays. Despite its high power requirements (Fig. 7), Mallory 1000, which is fabricated by special powder-metallurgy techniques, can be readily machined with tools similar to those used for high-strength grey cast iron. Thus, turning, boring, drilling, milling, and grinding present no problems, except for some tendency of the workpiece to break out at the outer edges of the cut. However, this tendency can be overcome by support close to the edge or by bevelling the edges. Mallory 1000 has generally good corrosion resistance and can be manufactured in pieces weighing up to 3000 lb.

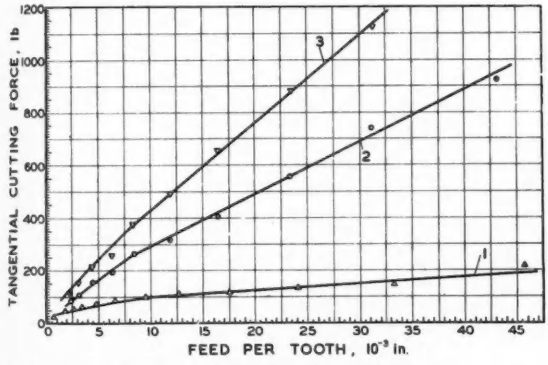


Fig. 6. (above) **Influence of feed per tooth on tangential cutting force when face-milling various materials, using a single-toothed face-mill of 8·4 in. diameter with a cast-iron-cutting grade of carbide.**
(1) Aluminium X-8001: Cutting speed 570 fpm; width of cut 1·88 in.; depth of cut 0·100 in.
(2) Natural uranium: Cutting speed 230 fpm; width of cut 1·44 in.; depth of cut 0·100 in.
(3) Mallory 1000: Cutting speed 230 fpm; width of cut 1·20 in.; depth of cut 0·100 in.

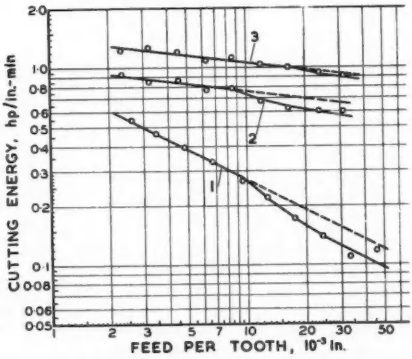


Fig. 7. (right) **Energy requirements, derived from Fig. 6, for face-milling (1) aluminium X-8001, (2) natural uranium, and (3) Mallory 1000.**

This material is easy to machine and requires no tools other than those generally recommended for aluminium alloys. The low forces and power required for milling are indicated in Figs. 6 and 7, which show the comparative values obtained with aluminium X-8001, and with the tungsten alloy Mallory 1000 and natural uranium, both of which are discussed below.

URANIUM

Most difficulties occurring in various machining operations with natural uranium metal, as well as uranium alloys (e.g., uranium-niobium), are due to work-hardening. It is true that some production shops[9] no longer consider the machining of uranium fuel elements to be an arduous job, but a number of precautions must be taken every time a radioactive material has to be handled and

machined. Thus, machines should be hooded and the air removed by an exhaust system. Natural uranium and uranium-niobium alloys can be handled under standard health and safety considerations for uranium-fuel fabrication facilities.

Pyrophoric characteristics must also be considered, and machining should be effected either under water or with a generous supply of coolant, which can be an emulsion, though plain mineral oil has also been used in milling operations. It has been found that an increase in niobium content tends to make machining operations somewhat more difficult. These materials usually have a hardness between 24 and 30 R_C and an ultimate tensile strength of 80,000 to 100,000 psi.

All machining operations, whether turning, drilling, or milling, should be performed with as heavy a feed and depth of cut as the dimensions and surface-finish tolerances permit. The tool should never be allowed to rub against the workpiece, so that a positive feed must be maintained, and tool irregularities causing rubbing cannot be tolerated.

Production milling of uranium-niobium alloy fuel elements has been carried out on standard milling machines with carbide cutters of the types shown in Fig. 8, which had positive rake angles and were run at a speed of 350 fpm and a feed of 8 ipm. The workpieces were 10 inches long, and about 100 lineal feet of material were milled per cutter grind. The surface finish depends on the feed per tooth when the cutting speed is constant, varying from 20 microinches r.m.s. for a feed of 0·003 in. per tooth to 120 microinches r.m.s. for a feed of 0·030 in. per tooth. The energy required in milling is indicated in Fig. 7, while the comparative factors of cutting energy required for face-milling uranium and other materials, related to a value of unity for SAE-1020 cold-rolled steel, are given below.

Mallory 1000	1·847
Uranium	1·245
Zircaloy-2	0·788
Aluminium X-8001	0·755
Aluminium 24S-T	0·612
Graphite	0·031

Drilling should be effected only with a sharp drill and with a power feed of 0·005 in./rev at about 80 to 120 fpm for high-speed-steel drills. The feed can be heavier if the drill will permit it; as a result, the length of the drill should not be more than required for the job in hand. Very small holes are usually drilled with a number of sharp drills in succession, the drills being changed after a short penetration of the uranium workpiece, in order to avoid dulling and work-hardening in the hole.

Tapping was found to be difficult when oil was used, but production improved with the application of molybdenum disulphide as a lubricant. Optimum performance was obtained with sharp taps at a cutting speed of about 30 fpm.

The grinding of uranium has been performed successfully with a vitrified silicon-carbide wheel of 46 grain size, *K* hardness, and 5 density at a workpiece peripheral speed of 70 fpm. A plentiful supply of coolant should be provided to eliminate the increased fire hazard associated with the fine chips.

Turning provides no particular problem, provided that the lathe is of sufficient power. Carbide tools with positive rake angles at cutting speeds up to 500 fpm have been used successfully, the optimum range being 120 fpm with a feed of 0·010 to 0·017 in./rev.

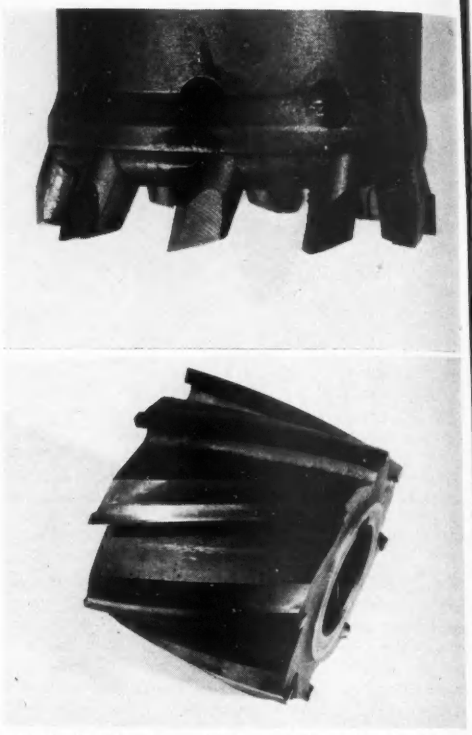


Fig. 8. Carbide cutters used in the production milling of uranium.

Plastic enclosures have been used advantageously for protection and as chip collectors. These enclosures can be filled with an inert gas or cutting fluid and still permit observation of tool performance, especially when turning and drilling.

GRAPHITE

Graphite is readily machinable, the energy requirements for face-milling a graphite block being, as already indicated, about 3% of that required for SAE-1020 steel. Surface pitting and tendencies to edge break-out of the workpiece appear to be dependent, among other things, on feed per tooth, a heavier feed being associated with more pronounced break-out and pitting. Tool wear is predominantly caused by abrasion of the flank or relief surfaces, and tool life decreases with an increase in cutting speed, in accordance with the normal exponential pattern. The chips produced may be in the form of large particles, somewhat resembling those obtained when machining cast iron. However, the swarf in machining some types of graphite material at higher speeds is in the form of finely divided particles appearing as a black, pervading fog. Adequate suction devices near the cut are necessary in such cases to keep the immediate atmosphere, the machine, and the surrounding area clean.

Standard cutting tools may be used but, to reduce tool wear, surface pitting, and tendencies to edge break-out, the harder cast-iron-cutting grades of tungsten carbide with positive rake angles of 15 deg. or more are recommended. Cutting speeds from 150 to 2500 fpm and feeds from 0·002 to 0·035 in. per tooth have been used with carbide tools. Lower speeds are naturally conducive to

a long tool life, and finer feeds reduce the number and size of surface pits and the degree of edge break-out.

CONCRETE

The machining of magnetite-concrete blocks and ceramic materials as parts of reactor structures has occasionally been required and usually has been found to be quite troublesome. In the machine shop, machining these materials often causes a dust problem, especially when using grinding wheels and similar tools, and the dust can also be damaging to other machine tools in the same area.

In this connection, it is interesting to note that a special machine for milling lightweight concrete blocks has been developed in Denmark by Ramboll and Olsen[10]. This machine finishes lightweight concrete blocks to a size of 8 × 8 × 16 in., the depth of cut generally being between $\frac{1}{4}$ and $\frac{1}{2}$ in. Carbide milling cutters with an abrasion-resistant type of carbide and only a comparatively small number of teeth have performed satisfactorily in such applications. These blocks are later glued together for housing structures, and their accuracy is such that prefabrication of complete sections is possible.

In early attempts at concrete-machining, the diamond-studded tools used created a real dust problem. With milling cutters, the chips are larger and granular, and are easy to collect, while the amount of dust is diminished, although a special collector is still required. Tool angles of + 6 deg. radial rake and — 8 deg. axial rake, with a general-purpose cast-iron-cutting grade of carbide, are satisfactory.

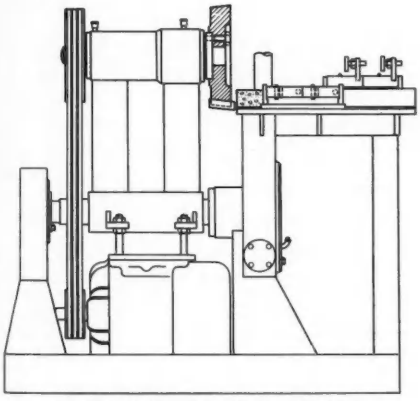


Fig. 9. Finishing machine for concrete blocks.

The machine, shown in Fig. 9, has a 5-hp motor and the cutter, 12 in. in diameter, holds 12 blades, the normal cutting speed being around 1400 fpm and the feed between 120 and 140 ipm. At higher cutting speeds dust presents more of a problem. The depth of cut was increased experimentally to $\frac{5}{8}$ and $\frac{3}{4}$ in. and with reduced feed, and no particular trouble was experienced, the practical limit of the depth of cut being the size and position of the blades in the cutter. Surface finish was about the same with sharp or dull cutters, and dimensional tolerances were held to within 0·004 in. Since these materials are rather brittle, there is a tendency for the workpiece edges to break out, but this can be avoided by having the finished cut as close as possible to the table edge. It was found that an overhang of $\frac{1}{32}$ in. was adequate, a larger overhang requiring a reduction in feed.

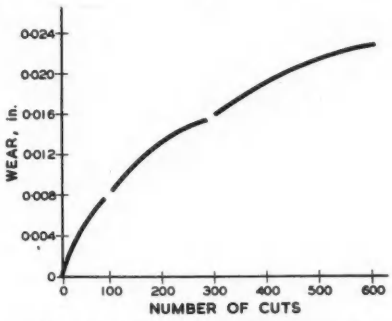


Fig. 10. Progressive tool wear when milling concrete blocks, using cuts of 4 × 16 in. and a cutting speed of 2700 fpm.

Wear of the cutter is similar to a grinding action, progressive increase in wear being illustrated in Fig. 10. As many as 3000 to 5000 blocks (i.e., 18,000 to 30,000 surfaces) were machined per cutter, and only slight adjustments of the cutter had to be made to maintain specified workpiece sizes.

PROTECTION AGAINST RADIATION AND TOXICITY

Many of the materials used in the construction of nuclear-reactor systems present special problems because of their toxicity or radioactivity[11]. These difficulties become even more significant when consideration is given to the problem of working with materials which have been activated by exposure in a reactor.

The fabrication of materials such as beryllium, cadmium, and lead may require the use of hoods and special ventilation systems to control the quantity of airborne material resulting from a machining operation. Special provisions may be necessary for the treatment of cutting fluids and coolants which become contaminated by thes materials.

Typical values for the permissible concentrations[12] in air [micrograms per millilitre] are 2×10^{-6} for beryllium, 1×10^{-4} for cadmium, $1{\cdot}5 \times 10^{-4}$ for lead, 5×10^{-4} for thorium, and $2{\cdot}5 \times 10^{-4}$ for uranium (insoluble). The fuel materials and fertile materials which may be transformed to fuel materials are all naturally radioactive. The radiation emitted by these materials predominantly comprises alpha particles, with some beta and gamma radiation, particularly in the case of plutonium.

The problem of protection from radiation from sources external to the body is not difficult for these materials, the major problem lying in the control of the concentration of these materials in the air. The maximum permissible concentration in air [microcuries per millilitre] is $1{\cdot}7 \times 10^{-11}$ for natural uranium, $1{\cdot}6 \times 10^{-11}$ for uranium 233, and 2×10^{-12} for plutonium 239.

An example of an approach to the solution of the problem of working with plutonium is afforded by the design of the fuel-fabrication facility at Argonne National Laboratory. Here, the entire fabrication area is maintained under a gauge pressure of — 0·075 in. of water to ensure that no contamination leaks out of the building. All operations on the material are carried out inside gastight hoods and must be performed by remote control or with neoprene gloves attached to parts in the enclosure system, permitting an operator to perform required manual operations from outside the gastight walls. A

gauge-pressure differential of 0·8 in. of water is maintained between the inside of the enclosure and the work area, so as to ensure that no contamination can leak out into the area occupied by personnel. The hood system operates with a filtered inert atmosphere to reduce the potential hazard occasioned by the pyrophoric nature of plutonium.

Radiation hazards associated with the machining of uranium metal and its alloys are much less severe than those associated with plutonium. Machine tools can be operated in the conventional manner, but a ventilation system with a filter arrangement is necessary to control the level of air contamination.

The storage and handling of fuel material must be planned to eliminate the possibility of accidentally assembling a critical mass. For any given enrichment of fuel, the mass and geometry which could cause criticality can be determined. In general, a " safe mass ", which is less than half the critical mass, will be the basis for fabrication operations.

The problems associated with the refabrication of fuel material after exposure to an intense neutron flux will demand special treatment, owing to the resulting intense radioactivity. The entire operation must be performed remotely, and the shielding required will be considerable. The flux of gamma radiation per gram of fuel removed from a reactor is given by the following rela-

(*Concluded on page 521*)

U. S. A.

Adhesive Bonding of Rare Metals

By R. F. WEGMAN and M. J. BODNAR. (From *Machine Design*, Vol. 31, No. 20, October 1, 1959, pp. 139–140, 1 illustration)

MANY rare and unusual metals have outstanding heat resistance and chemical stability, and where applications of these materials require smooth surfaces, free from irregularities, adhesive bonding is generally specified. As, however, bondability data are not readily available, it is considered that the results of the adhesion tests reported in this article should be of special interest.

For these tests, steel specimens were bonded to different metals and alloys, as listed in Table I, using two types of adhesives, i.e., adhesive "A" (a modified, filled novolac epoxy), and adhesive " B " (a rigid, modified polyester). The tensile strength of the adhesive bonds in each case is also shown in Table I. Additional tests were carried out on steel bonded to uranium 238 but, owing to the special problem involved in bonding to uranium, two other adhesives were used, these being an epoxy modified with a polyamide, and a cured polyurethane, the results in this case being approximately the same, i.e., 1184 psi for the modified epoxy and 1300 psi for the polyurethane adhesive.

TABLE I: ADHESIVE-BOND STRENGTH AT 73·5°F.

Steel Bonded to	Tensile Strength [psi]	
	Adhesive "A"	Adhesive " B "
Beryllium	4820	4640
Columbium	5010	3400
Copper-beryllium	6240	3940
Molybdenum	4840	4575
Palladium	5200	4315
Rhenium	6410	3255
Tantalum	4100	3300
Tungsten	5470	5025
Mn-Cu-Ni alloy	3600	3135
Zirconium	5490	3590

Similar tests were also carried out with adhesives "A" and " B " on chromium, gold, silver, stainless steel, and titanium bonded to themselves, the respective results for adhesives "A" and " B " being as follows:—Chromium (7160 and 5010 psi), gold (8610 and 3950 psi), silver (3780 and 5625 psi), stainless steel (8500 and 6070 psi), and titanium (9920 and 5665 psi). Comparisons of these figures and those in Table I show that adhesive "A" provided a higher bond strength to all metals than adhesive " B ", except in the case of silver. The lower results obtained with silver are, however, to be expected, since the novolac epoxy adhesive "A" is modified with a polysulphide polymer which readily attacks metallic silver.

For these tests, no special cleaning procedure was used for preparing the metal surfaces. The specimens, with certain exceptions, were vapour-degreased with perchloroethylene before applying the adhesive, the exceptions being beryllium, uranium, stainless steel, and titanium. Beryllium and uranium form oxides which were removed by special abrading processes, while stainless steel and titanium were treated by cleaning with a dilute solution of chromic acid.

In all cases where the metals were bonded to steel, the specimens were prepared by sandwiching the metal between two steel tensile pieces, Gold, silver, and chromium were plated onto the bonding surfaces of standard tensile pieces. With the exception of beryllium and uranium, the bonded area of each test specimen was 1 sq in. The beryllium had a surface bonding area of 0·785 sq in., and the uranium 0·56 sq in. All specimens were cured at room temperature. Tests were conducted at a constant rate of load increase, applied at 600 to 700 psi per minute.

These tests show that good bonds were obtained with adhesives "A" and " B ". The degree of adhesion obtained also indicates the success that can be expected when polymeric materials are used as sealants or encapsulating compounds with these metals. Penetration of moisture through a sealed area depends not only on the moisture resistance of the sealant and adherend, but also on the extent to which the moisture can penetrate the interface area between the sealant and adherend. Generally, if a low degree of adhesion is experienced between two surfaces, moisture may conceivably penetrate the sealed joint through microscopic voids.

Finally, it should be noted that, although the data shown are for specific metal-to-metal bonded joints, the approximate bond strengths obtainable can be calculated for any combination of the metals reported here. For example, if columbium were bonded to gold, the results would be expected to be no better than the adhesion to columbium. At room temperature, the bond strength obtained will always be equal to the bond strength obtainable for the metal with the lowest surface-adhesion properties. At other temperatures, differences in thermal coefficients of expansion may have to be considered.

Economic Production of High-Precision Steel Balls

By H. GRÖBNER. (From *Werkstattstechnik*, Vol. 49, No. 9, September 1959, pp. 497–501, 17 illustrations)

THE increasing demand for accuracy in the aircraft, motor-vehicle, and electrical industries imposes very stringent requirements on ball-bearing components. The accuracy of the balls, insofar as their diameter and uniformity in a given bearing and their surface quality are concerned, depends on their grinding and lapping treatments, which also determine their load-carrying capacity, reliability, and running smoothness. In fact, it may be said that, in the production of high-precision balls, other stages of manufacture are of minor importance, compared with grinding and lapping operations.

One manufacturing method comprises subjecting the balls, after pressing, to a combined rolling and indenting treatment, sometimes incorrectly known as a "filing" treatment. However, this rolling-indentation process is not only time-consuming, but is also expensive. As a result, another method is used to some extent, this process being designated a grinding process, though closer examination shows it to be more akin to a type of crushing process. In this method, the balls are located in a tapered recess between two annular surfaces *a* and *b*, as shown in Fig. 1, and are pressed against an upper supporting ring *c*. This ring and the grinding wheel beneath it rotate

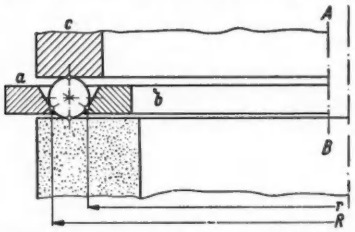


Fig. 1. Schematic arrangement of the conventional grinding process.

about different centres. When the supporting ring *c* is rotated about its axis *AB*, the balls rotate about their horizontal axes. At the same time, however, they rotate about their vertical axes, because their supporting points at the base of the tapered recess are at two different radii *R* and *r*, so that different peripheral speeds are imparted to them on opposite sides by the edges of the annular surfaces. The amount of eccentricity between the centre of rotation of the grinding wheel and that of the supporting ring *c* is determined by the radial dimensions of the grinding wheel.

In this process, since the grinding wheel and the balls run in the same direction, the result is not a true grinding operation in the usual sense of the term, but rather a rotary crushing operation. Moreover, only one row of balls can be shaped at a time, so that this process is also uneconomical, though it has definite advantages over the rolling-indentation process.

After processing, the balls are subjected to lapping operations in several stages, using different grades of corundum for each stage. It should be appreciated, however, that, with conventional methods of processing, it is not possible to produce a batch of balls with deviations in diameter from the required value of less than 0·5 micron. As a result, the balls produced are selected according to their diameter in ball-grading machines, the degree of grading depending on the sensitivity of the equipment used. However, as the balls have different out-of-roundness errors, as well as different diameters, it is quite possible for a given ball to be graded in different sizes if it is passed again through the grading equipment, as will occur if the first measurement is taken over its maximum width and the second over its minimum width.

On the basis of a study of the production processes hitherto employed, a new ball-grinding and lapping process, which avoids the disadvantages of previous methods, has now been developed. The balls, after the pressing operation, are ground by means of a conventional grinding wheel in a direction perpendicular to their carrier plate, using a process which is similar to centreless grinding.

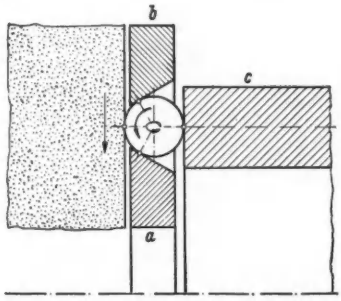


Fig. 2. Schematic arrangement of the new grinding process.

The new arrangement is shown in Fig. 2. As the grinding wheel acts on the ball in a direction perpendicular to the plane of the carrier plate, the ball is rotated about its horizontal axis, as in the process shown in Fig. 1. It differs, however, from this process in that the axis of the supporting ring *c* is situated vertically, instead of horizontally. Rolling is obtained by using a circular ring for the carrier *a*, around which an outer ring *b* is arranged. When the supporting ring *c* rotates, the balls are pressed into the vee-shaped recess and contact the sides of both rings *a* and *b*, so that they rotate simultaneously about their vertical and horizontal axes, making it possible to produce a really round ball. The grinding wheel approaches the ball at right-angles to the supporting surface, as shown in Fig. 3, resulting in a true grinding operation, with the balls subjected to a continuous process.

The output of this type of machine is many times greater than that of the arrangement shown in Fig. 1, the time re-

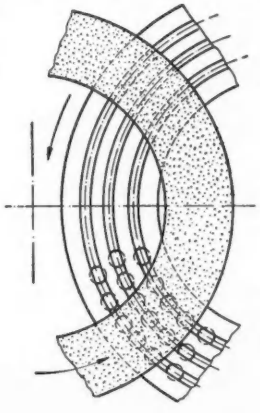


Fig. 3. Overlap of grinding-wheel and ball tracks in the new process.

quired to remove a given amount of material being about fifteen times less for the same container capacity and wheel size. A further advantage is that the ground ball has a comparatively smooth surface—an important consideration where their subsequent treatment is concerned.

In this new process, hardening treatment is followed by lapping operations between two cast-iron discs, the arrangement used for this operation taking into account the experience gained in the manufacture of end-gauges, in which the workpiece slides between upper and lower lapping wheels, owing to the greater peripheral speed of its outer end, so that very intensive lapping is obtained.

Similarly, in ball manufacture, the lapping action can be obtained by the different points of support of the ball. The ball is in contact with the upper lapping wheel at one point only (Fig. 4) and tries to roll out in a tangential direction. This is prevented, however, by its two-point contact with the sides of the groove in the lower wheel. Thus, the ball is obliged to follow a circular path and, besides rotating about its horizontal axis (owing to the different radii of its contact points from the wheel centre), it rotates about its vertical axis. The quality of this lapping process depends on the correct selection of the relative values of these two rotations, the resulting movement producing the sliding motion which causes lapping.

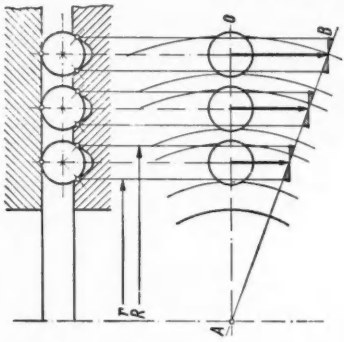


Fig. 4. (above) **Lapping method, with three-point contact, used in the new process.**

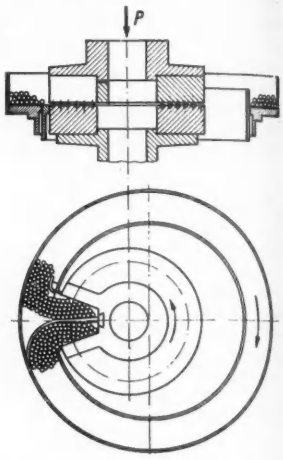


Fig. 5. (right) **Schematic arrangement of the ball container used for lapping operations in the new process.**

The reduction in diameter of the balls is achieved very rapidly and, because of this rapid reduction, the new ball-grinding and lapping equipment is provided with a peripheral-drum type of container horizontally arranged around the lapping wheels (Fig. 5), enabling a considerably increased quantity of balls to be fed to the lapping wheels. The container feeds the balls in a continuous flow into the lapping-wheel grooves and receives them again at their exit. The guiding arrangement is so designed that satisfactory mixing of the balls is achieved; in other words, balls which have gone round in an inner groove will then pass round an outer groove, and vice versa, any other movement of the balls, besides that required for their mixing, being eliminated. Heat acquired by the balls can be dissipated in the container, which is constructed in such a way that any ball which has been lapped will only go through the lapping wheels again when the entire charge has passed through the machine, ensuring uniformity of the balls.

The horizontal disposition of the container ensures that the balls have a uniform diameter. If a vertical container were used, lapped balls would be mixed with unlapped balls after each cycle, an undesirable drumming action would occur between the various lapping processes, and the machine would receive both large and small balls in its grooves. The lapping action would then only affect the larger balls, while the small balls would run round freely. Consequently, a vertical container arrangement would tend to lengthen the process, instead of shortening it.

By means of this new method it is now possible to produce high-precision balls with a diameter tolerance of 0·2 to 0·3 micron, without resorting to grading equipment, since the tolerance applies to the entire charge. Moreover, the output of the machine with a horizontal container is about 35% higher than that of a conventional machine of the same grinding power, the same grinding wheels, and the same container capacity.

The efficiency of the manufacturing process is increased if three machines of the same type are used for processing the balls after the hardening treatment. The first machine has wheels with corundum of grain sizes of 100 to 150, the second has grain sizes up to 500, and the third serves only for producing the final mirror finish with any suitable polishing medium.

The advantage of having three machines is that each can be provided with lapping wheels of a different grain size. With one machine, even if it were cleaned thoroughly after each lapping stage, it would not be possible to remove all the embedded particles of corundum of a different size without machining the lapping wheels. It is therefore more economical to keep each machine to a specified grain size, and to provide conventional washing equipment between each of these units for the removal of corundum from the balls after each stage.

The use of two lapping machines is sufficient when they are to be employed only for improving an existing product, i.e., in combination with a number of machines of older types. Although the new machines can also produce geometrically round balls within a specified tolerance from balls supplied to them with very considerable out-of-roundness errors, the time factor involved is of importance. The final stage of the treatment is carried out with a very fine polishing medium, so that very little material is removed at this stage. Now, if the machines are supplied with balls of different diameters and shapes, obtained by conventional manufacturing methods, the time required to reduce them to correct size would be considerable, since the lapping wheels must first act on the largest balls and reduce these gradually until the small balls are dealt with. Experience indicates that, when balls are to be put through an improving process, it is far more economical to lap them first in one machine of the new type, using a coarse-grade corundum, until they are of equal size and have a geometrically round shape, before passing them to the second machine for the final polishing treatment.

U.S.A.

The Principles and Properties of the Tunnel Diode

By B. Sklar. (From *Electronics*, Vol. 32, No. 45, November 6, 1959, pp. 54–57, 8 illustrations)

Although calculations showing that the tunnel effect was possible were made as long ago as 1929, it is only recently that this effect has been utilized in the development of the tunnel diode, following the results disclosed by the Japanese physicist Esaki of his research into the tunnel effect in thin semiconductor junctions.

The tunnel diode derives its name from the quantum-mechanical tunnelling which characterizes its unique operation. In highly doped *p-n* junctions, the majority charge carriers can tunnel through the junction barrier and appear at the speed of light at the other side. The device exhibits a voltage-controlled negative conductance which suits it for many applications as an oscillator, amplifier, or switching element, and has a predicted operating range beyond 10,000 Mcs. Furthermore, it has many advantages over the transistor, being smaller, cheaper, more reliable, and more resistant to radiation, with a greater temperature range and a much higher cut-off frequency.

In an insulator (Fig. 1a), the highest energy band containing electrons is filled and separated from the empty band above it by a forbidden region of several electron-volts. There are no available states for electrons within this forbidden region. A large amount of energy is required to raise an electron from the top of the filled band (valence band) to the bottom of the empty band (conduction band). Once in the conduction band, the electron is disassociated from its atom and is free to move through the lattice.

Fermi level is defined as that energy level where the probability of an available state being occupied by an electron is equal to 50%. For an insulator, the probability of occupancy of the conduction-band states is zero and the probability of occupancy of the valence-band states is unity; therefore, the Fermi level must exist at the centre of the forbidden region.

In a conductor, the highest band containing electrons overlaps the first empty band, as shown in Fig. 1b. This partially filled band can be considered as the conduction band, and the filled band below it the valence band.

The electrons in the conduction band require little energy to move to an empty level In so doing, the electrons become disassociated from their atoms and are free to move.

For a conductor, the energy level corresponding to a 50% probability of electron occupancy (Fermi level) is also the maximum possible energy that an electron may have in the crystal at a temperature of absolute zero. The Fermi level of a conductor always appears in the conduction band.

The energy band diagram shown in Fig. 1c for an intrinsic (pure) semiconductor is similar to the insulator diagram. However, instead of the forbidden region extending over several electron volts, the gap in the semiconductor has a much smaller value, being equal to approximately one electron volt. Since this is a relatively small energy gap, some electrons have sufficient thermal energy at room temperature to surmount the forbidden region and appear in the conduction band.

The result of a valence electron crossing this gap is referred to as the formation of an electron-hole pair; in other words, a negatively charged electron becomes free to move in the conduction band, and a positively charged hole (the absence of an electron) is correspondingly free to move in the valence band. Each of these charged particles contributes to current flow and is generally referred to as a carrier. The Fermi level for the intrinsic semiconductor is at the centre of the forbidden region.

Extrinsic (doped) semiconductor materials are either *n*-type (excess of electrons) or *p*-type (excess of holes). Figure 2a illustrates the energy-band diagram for an *n*-type material and reveals a new energy level E_D corresponding to the donor doping material and appearing slightly below the bottom of the conduction band E_C. A small amount of energy is necessary for donor electrons to escape from the donor level and rise to the conduction band.

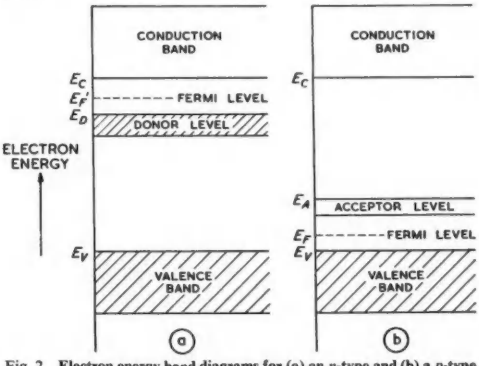


Fig. 2. Electron energy band diagrams for (a) an *n*-type and (b) a *p*-type doped semiconductor material.

At absolute zero there is no thermal energy available for any donor electrons to appear at E_C, so that the Fermi level is found midway between E_C and E_D since it prescribes total occupancy below that level and total vacancy above it. As the temperature increases and electrons gain enough thermal energy to escape into the

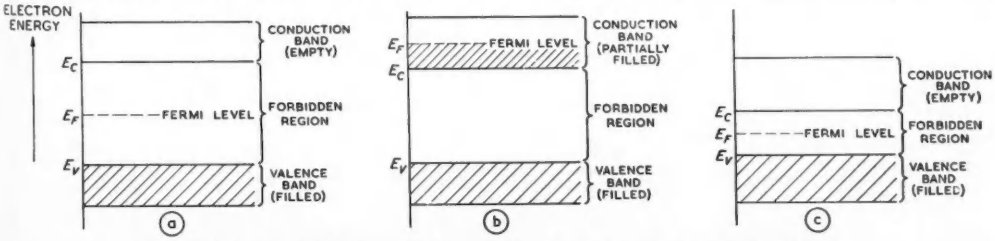


Fig. 1. Electron energy band diagrams for (a) an insulator, (b) a conductor, and (c) a pure semiconductor.

conduction band, the Fermi level falls until, at a high enough temperature, it approaches the intrinsic case.

Fig. 2b illustrates the energy band diagram for a *p*-type material, and reveals an energy level E_A corresponding to acceptor doping and appearing slightly above the top of the valence band.

It can be shown that the Fermi level in *p* material is found midway between E_V and E_A at absolute zero and rises with increasing temperature until it also approaches the intrinsic case.

If *p*-type material is joined to *n*-type material in the formation of an ordinary diode there is, at the instant of junction, a higher concentration of holes in the *p* material than in the *n* material, resulting in a diffusion of holes into the *n* material. Simultaneously, there is a diffusion of electrons into the *p* material. The diffusive flow quickly results in a net negative charge caused by immobile acceptor ions at the *p* surface and a net positive charge caused by immobile donor ions at the *n* surface. The boundary region between the *p* and *n* sides becomes devoid of holes and electrons, and is known as the depletion region.

A potential difference or barrier is established at the junction because of the field generated by the exposed charges. The Fermi level can be considered as a level depicting the average energy associated with the electrons of the crystal.

With reference to Fig. 2, assume that *p*-type material is to be joined to *n*-type material. Since, at equilibrium, the average energy of each half of the resulting slab must be equal, the Fermi levels E_F and E_F' must line up at the same energy level. Consequently, the *p*-type diagram can be considered as moving up and the *n*-type diagram moving down with respect to each other.

Tunnel-Diode Characteristics

The difference between the characteristics of an ordinary diode and a tunnel diode is shown in Fig. 3. As the impurity concentration is increased in the ordinary diode, the breakdown voltage decreases, as shown by the dotted line in Fig. 3a. When the impurity concentration increases to about 6×10^{19} atoms per cm³ (for silicon), the semiconductor begins to resemble an alloy, and the characteristic is in the breakdown condition at zero and even slightly positive bias, as shown in Fig. 3b.

For all back-biasing, the diode is highly conducting in the reverse direction; for small forward-biasing, the current increases linearly with voltage in the forward direction until it reaches a peak. With increased forward bias, the forward current then drops to a minimum, thereby manifesting the negative conductance peculiar to the tunnel diode. This forward current at low forward bias, which disappears with increased bias, is called the Esaki current.

With still larger positive bias the characteristic increases in the same way as an ordinary diode. Unlike the usual breakdown curve which occurs over a range of reverse bias, the breakdown region here extends from a small positive bias (approximately 50 to 100 mV for germanium) to all negative biases. As the tunnel diode goes into breakdown, the current flow decreases until reversal takes place. This is so different from the usual breakdown condition that probably the term breakdown is not applicable.

Two important criteria for making a tunnel diode are heavy doping, of the order of 10^{20} atoms per cm³ (for silicon) and an extremely thin depletion region of the order of 100 Å. Since the depletion width of an abrupt

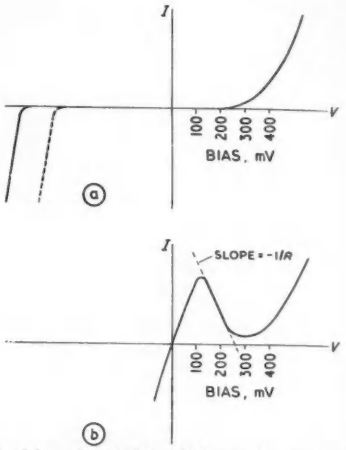


Fig. 3. Breakdown characteristics of (a) an ordinary germanium diode and (b) a germanium tunnel diode.

junction is an inverse function of the doping concentration, a high enough impurity concentration and an abrupt junction will satisfy the latter criterion.

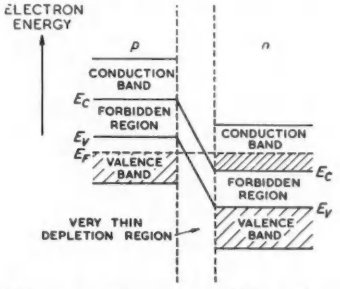


Fig. 4. Electron energy diagram for a highly doped *p-n* junction.

Fig. 4 is an energy band diagram for a highly doped *p-n* junction. The cause of the negative conductance is that the semiconductor is so highly doped that it is degenerate and resembles an alloy (in fact, it is sometimes called a semimetal); in addition, unlike moderately doped semiconductors, the Fermi level E_F in the degenerate case is in the conductance band for *n*-type material and in the valence band for *p*-type material. Consequently, when the junction is formed and the Fermi levels line up, the diagram is different from that of an ordinary diode. In the case of the highly doped *p-n* junction, there are some electrons in the *n*-material conduction band which have the same amount of energy as some electrons in the *p*-material valence band.

With a small amount of positive bias (Fig. 5a), the junction barrier is decreased, and *n*-material conduction electrons are situated opposite *p*-material available states at the same level of energy. Quantum-mechanics dictates that, under this condition, there is a finite probability that an electron originally on one side of the junction can appear on the other side at the same energy level by tunnelling through the barrier at the speed of light. The tunnelling probability can be made high enough to support large currents.

With increased positive bias, the junction barrier is further decreased, and the *n*-material conduction elec-

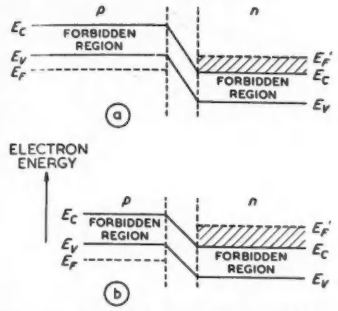


Fig. 5. **Electron energy band diagrams for a tunnel diode with (a) a small positive bias and (b) an increased positive bias.**

trons are opposite the *p*-material forbidden region, as shown in Fig. 5b. As a result, there are no available states to which the electrons can tunnel and the current (theoretically zero) is small, as indicated by the valley in the characteristic shown in Fig. 3b. The current has decreased with increased positive voltage, thus demonstrating negative conductance. Further increase of positive bias results in sufficiently decreasing the junction barrier, so that carriers can surmount it and contribute to current flow, as in ordinary diodes.

Advantages of Tunnel Diodes

The concept of amplification by the use of negative conductance is not new, but the lack of a convenient device has made the use of such amplifiers unattractive. It now appears that the simple inexpensive tunnel diode will reawaken interest in negative-conductance amplifiers.

Tunnel-diode amplifiers have gain-bandwidth products and noise factors considerably better than those of grid-controlled electron tubes. One of the most impressive features is the wide temperature range over which the negative characteristic can be obtained, i.e., from 4·2°K (liquid helium) to over 400°C for silicon devices. Also, in a radioactive environment, a conventional transistor is badly degraded, because radiation shortens the life of the minority carriers; however, since tunnel diodes operate by the flow of majority carriers, they are particularly resistant to radiation effects.

Many circuits have already been built with tunnel diodes, including amplifiers, oscillators, converters, r.f. detectors, limiters, flip-flops, and various switching devices which respond within a fraction of a millimicrosecond and require very little power.

It should be noted, however, that the device has one drawback:—At present, it is not possible to couple several stages easily and to obtain a unidirectional circuit, the problem of isolating output from input being inherent in all two-terminal devices.

SWEDEN

Investigations into the Effectiveness of Compensating Thermo-Electric Currents for Reducing Cutting-Tool Wear

By G. Engstrand. (From *Transactions of the Royal Institute of Technology, Stockholm*, Vol. 144, Mechanical Engineering Series No. 5, 1959, 9 pages, 6 illustrations)

A contributory cause of cutting-tool wear is the fact that the oxygen in the air gives rise to oxidation of the tip material in the course of machining, the process of oxidation being considered to be due to the influence of ions. If the cutting tool is provided with a cemented-carbide tip, oxidation of the carbides is caused by an accumulation of oxygen on the surface, where it is ionized by free electrons and acquires a negative charge. The oxygen ions travel into the interior of the carbide and are bound to the positive metal atom. At the same time, the negative carbon leaves the carbide in order that the electron neutrality may be maintained.

At a State research institute in Nordrhein-Westfalen, Germany, attempts have been made to influence the process of oxidation so as to reduce the wear of tools. The zone of contact between the cemented-carbide tip (1) and the steel roll (2) to be machined acts as a thermo-electric junction in a thermocouple, as shown in Fig. 1. The heat generated at the cutting point in the course of turning produces at this point a thermo-electric current flowing in a circuit which is insulated from the lathe. This circuit comprises the tool (1), the work (2), the mercury contact (3), the series resistor (4), the voltage divider (5), the switch (6), and the ammeter (7), through which the current returns to the tool (1). The thermo-electric current produced at the junction is compensated by the aid of a source of current (8) and a switch (9). According to Opitz and Axer, in order to reduce oxidation the direction of the compensating current must be chosen so as to be opposite to that of the thermo-electric current normally obtained at the junction. The resulting current can be regulated with the help of the voltage divider (5) within a range extending from zero to low or high overcompensation. The rotating mercury contact (3) ensures a low contact resistance.

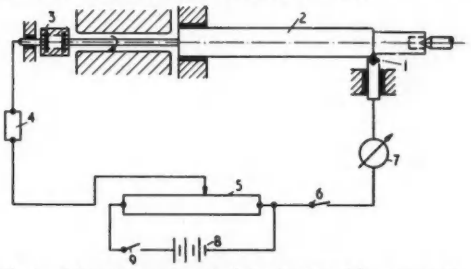


Fig. 1. **Schematic arrangement of the circuit used for compensating thermo-electric currents produced at the cutting point.**

The results obtained in Germany have been subjected to experimental verification at the Royal Institute of Technology, Stockholm. The German investigation was made on cemented-carbide tools used for cutting different materials, while varying the machining data, flank wear being measured and plotted as a function of machining time. When the thermo-electric current was compensated, the life of the cutter bits was found to be longer than in normal turning. In the tests carried out in Sweden, attempts were made to ensure a greater accuracy in

measurements and to reduce the requisite amount of material. For this purpose, use was made of a radioactive cutter bit, and tool wear was determined by measuring the radioactivity of the chips produced.

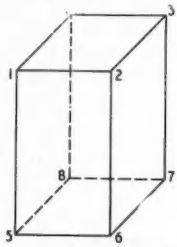


Fig. 2. Cutting edges Nos. 1 to 8 of the cemented-carbide tip.

The workpiece employed in these tests was made of annealed 0·7% carbon steel (Brinell hardness number 180 kg/mm², diameter 150 mm, length 1250 mm). A tool with a cemented-carbide tip, measuring 10 × 10 × 18 mm, was activated in a nuclear reactor in a flux of 3×10^{11} neutrons/cm²-sec for 3·5 hr. The work was turned for periods lasting 4 min each, the total machining time being 20 min for each of the cutting edges Nos. 1 to 6 in Fig. 2, according to the following shedule:—

Cutting edge No. 1:—Open circuit.
Cutting edge No. 2:—Short-circuit conditions.
Cutting edge No. 3:—Circuit compensated to 0 A.
Cutting edge No. 4:—Circuit overcompensated to 0·01 A.
Cutting edge No. 5:—Circuit overcompensated to 0·1 A.
Cutting edge No. 6:—Circuit overcompensated to 0·5 A.

Cutting edges Nos. 7 and 8 were used in a subsequent check test, in which the effective machining time was 24 min per cutting edge. Cutting edge No. 7 was employed for turning in three periods of 4 min each under short-circuit conditions, and then in three periods of 4 min each while the circuit was overcompensated to 0·5 A. In the test on cutting edge No. 8, this sequence was reversed, whereas the machining time was unchanged, i.e., the circuit was first overcompensated to 0·5 A for 12 min, and then short-circuited for 12 min.

In the course of all machining operations, the tool and the work were insulated from the lathe, frame, etc., as in Fig. 1. The diagram of connections of the circuits

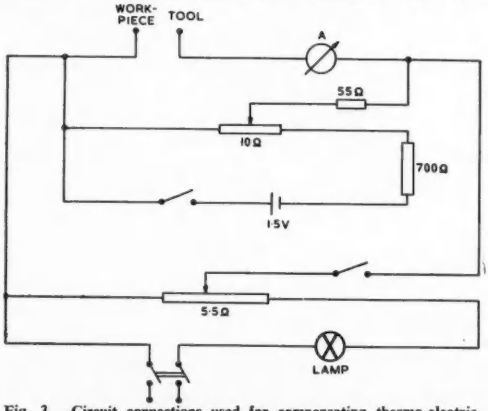


Fig. 3. Circuit connections used for compensating thermo-electric currents generated at the cutting point.

used for compensation of the thermo-electric current generated at the tool point is shown in Fig. 3. The inner circuit, which comprised a 1·5-V storage battery, was employed for compensation to 0 A, while the outer circuit, which was fed from the supply mains (220 V, d.c.) was utilized for over-compensation in three stages, as mentioned above. The incandescent lamp served as a series resistance, and also as a signalling device.

Test Results

In these tests, the machining data and cutter-bit geometry were as follows:—Cutting speed = 80 m/min; feed = 0·41 mm/rev; depth of cut = 2 mm; angle of approach = 60 deg.; relief angle = 7 deg.; side rake angle = —7 deg.; back rake angle = 0 deg.; and nose radius = 0·8 mm.

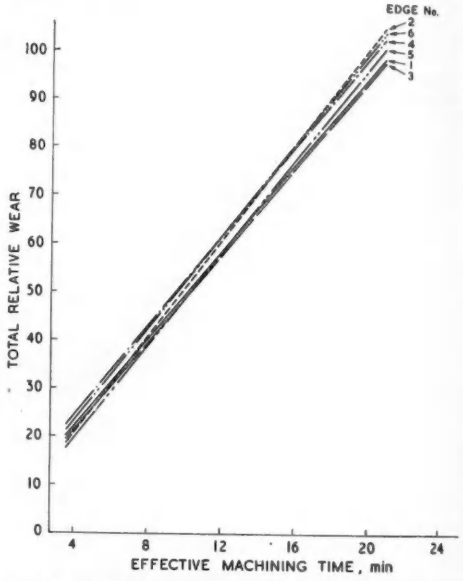


Fig. 4. Total relative wear of the cutter bit, in terms of the total radioactive count per minute of the chips, as a function of effective machining time with cutting edges Nos. 1 to 6.
No. 1:—Open circuit. No. 2:—Short-circuit conditions.
No. 3:—Compensation to 0 A. No. 4:—Overcompensation to 0·01 A.
No. 5:—Overcompensation to 0·1 A. No. 6:—Overcompensation to 0·5 A.

Since the cutting edges in the present investigation were used for turning the same material under identical machining conditions, the observed values of wear of the different cutting edges can be directly compared. As can be seen from the curves in Fig. 4, which shows the total relative wear of the cutter bit, expressed in terms of the total radioactive count per minute of the chips produced, as a function of effective machining time with the cutting edges Nos. 1 to 6 in Fig. 2, the values of the total relative wear, i.e., the sum of the flank wear (bevel edge) and the cutting-face wear (crater), relating to these six cutting edges are practically equal. It is obvious that neither opening and short-circuiting the circuit nor compensating the circuit in four stages had any effect on tool wear. An extremely weak individual trend may possibly be detected in the curve relating to short-circuit conditions (cutting edge No. 2), i.e., to ordinary machining, this curve having a slightly greater slope than the other five

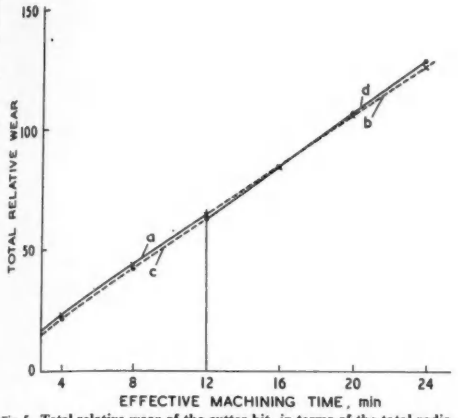


Fig. 5. **Total relative wear of the cutter bit, in terms of the total radioactive count per minute of the chips, as a function of effective machining time with cutting edges Nos. 7 and 8.**
(a) Short-circuit conditions (cutting edge No. 7).
(b) Overcompensation to 0·5 A (cutting edge No. 7).
(c) Overcompensation to 0·5 A (cutting edge No. 8).
(d) Short-circuit conditions (cutting edge No. 8).

curves. Furthermore, the wear-time curves of cutting edges Nos. 1 and 3 completely coincide during the whole machining time. This result is also theoretically correct.

The results of the check tests on cutting edges Nos. 7 and 8 in Fig. 2 are shown in Fig. 5, in which it will be noted that there is no appreciable difference in the slope of the curves (i.e., in the relative wear per unit time) between the first and the second 12-min machining periods, despite the fact that comparison has been made between machining conditions which are theoretically most unfavourable and most favourable (i.e., short-circuit conditions and circuit overcompensated to 0·5 A respectively). It should also be noted that the author has not been able to observe any changes in tool life during his earlier investigations, where machining in conjunction with compensation of the thermo-electric current produced at the cutting point was compared with normal machining.

In conclusion, it may be said that, although these tests were carried out under laboratory conditions, they did not show any noticeable improvement in tool life. Accordingly, it appears that the method of reducing tool wear by compensation of thermo-electric currents is of no practical importance, at any rate not at the present stage of development.

RUSSIA

Automatic Machining Line for Spur Gears

By U. N. Pisarev and E. Kh. Reuterstein. (From *Traktori i Selkhozmashini*, No. 6, 1959, pp. 40–46, 6 illustrations)

In the construction of Russian automatic production lines, there is a distinct tendency towards those lines which can readily be retooled for the manufacture of components of different design and dimensions. Obviously, the object is to ensure that nearly identical and hence cheaper production lines can be supplied for the manufacture of different items and that they can also be used in factories where components of one particular size are not produced in large quantities, ensuring the continuous operation of a costly specialized automatic line.

An example of this trend is a line for the automatic machining of spur gears, designed in Russia by the Experimental Research Institute for Machine-Tool Construction. With very little retooling, this line can handle gears of ten different designs, of 100 to 250 mm o.d., 30 to 160 mm bore, and 3 to 5 mm module. The yearly output of this line is stated to be over 120,000 gears, using only nine operators, each of whom produces about 13,400 gears per year, as compared with about 4000 gears produced by an operator by conventional mass-production methods. The plant includes nine machine tools, occupies a floor space of about 80 m², and is powered by motors of about 120 kW total capacity. By comparison, an equivalent output by mass-production methods requires nineteen machine tools, a floor space of about 170 m², and motors of about the same capacity. Furthermore, the total machining cost of one gear by the new line is about 25% less than by conventional mass-production methods.

The automatic line (Fig. 1) is divided into two independent sections. Before entering the second section, the components are manually inspected. After leaving the second section, which consists entirely of -gear-cutting and finishing machines, the components are washed and inspected, these operations not being included in the automatic cycle.

The close-tolerance blanks used are made on crank-type forging presses, enabling the loss of material to be reduced to only 25% by weight. The blanks arrive at the line on special trolleys, loaded in stacks on long pins. At the automatic store in front of the machine, an automatic transfer head initiates the automatic cycle by lifting the blanks from the trolley pin and loading them onto a longitudinal conveyor. At each machine-tool station, there is an automatic loading-unloading unit which lifts the work from the conveyor, transfers it to the loading station of the machine, and returns the machined work back onto the conveyor. The schematic arrangement of the automatic transportation system used is shown in Fig. 2. At the end of each section, an automatic transfer head places the workpieces on the pins of the automatic rotary stores.

All machining operations are carried out on standard Russian machine tools, which are also used in normal production, the sequence of operations for machining a spur gear being as follows:—

(a) Rough-turning the outer diameter, and boring, finish-facing, and chamfering on one side. For turning operations, the cutting speed is 170 m/min, and the feed is 0·35 mm per revolution. For chamfering, these values are 45 m/min and 0·68 mm/rev respectively. The cycle time is 106 sec, of which the machining time is 75 sec.

(b) Rough-turning the outside diameter, facing, and chamfering the other side, and finishing the bore. For turning, the cutting speed is 170 m/min and the feed

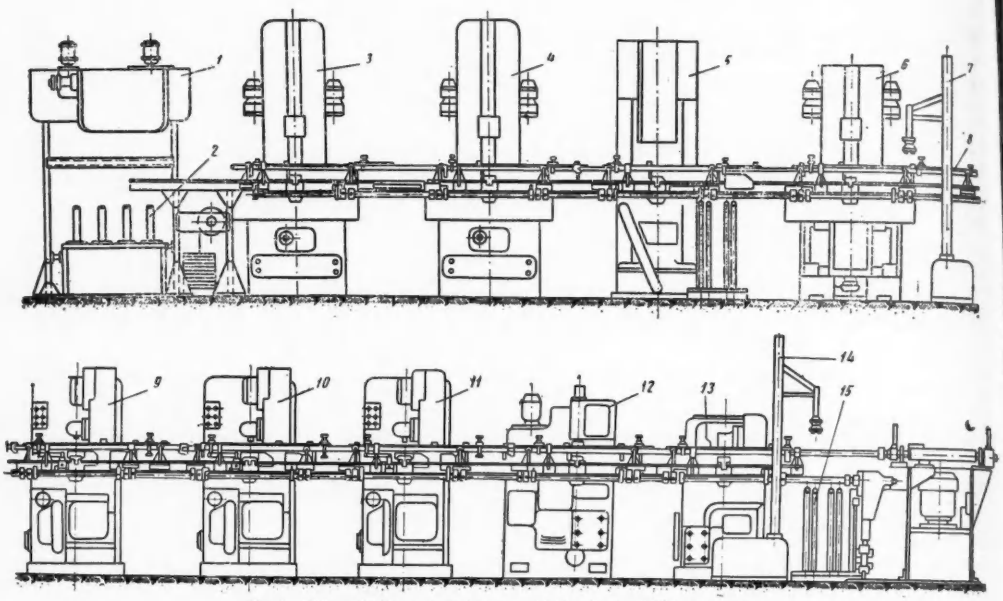


Fig. 1. Schematic diagram of the automatic line for machining spur gears.

(1) Automatic store. (2) Special trolley for gears. (3), (4), (6) Vertical automatics. (5) Automatic vertical broaching machine. (7), (14) Transfer heads. (8) Transport and loading-unloading equipment. (9), (10), (11) Automatic hobbing machines. (12) Tooth-chamfering machine. (13) Shaving machine. (15) Pins.

0·35 mm/rev. For facing, these values are 170 m/min and 0·5 mm/rev, and for chamfering 48 m/min and 0·68 mm/rev respectively. The cycle time is 96 sec, of which the machining time is 65 sec.

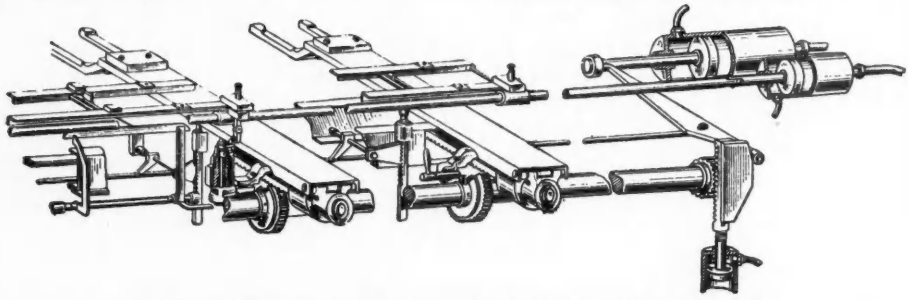


Fig. 2. Schematic arrangement of transportation and loading-unloading equipment used in the plant.

(c) Broaching the bore and splines, using a cutting speed of 1 m/min and a feed of 0·065 mm per tooth. The cycle time is 16 sec.

(d) Finish-turning the outside diameter and facing, using a cutting speed of 216 m/min and respective feeds of 0·35 mm/rev and 0·25 mm/rev. The cycle time is 76 sec, of which the machining time is 41 sec. This operation is followed by inspection.

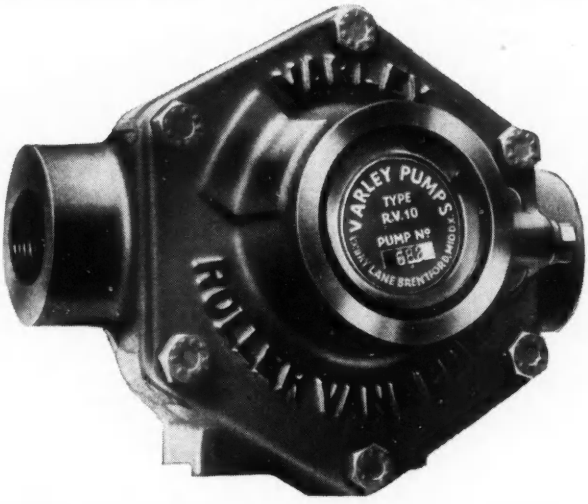
(e) After inspection, the gears are hobbed, using a cutting speed of 45 m/min and a feed of 6·1 mm/rev, the cycle time being 341 sec, of which the machining time is 312 sec.

(f) Chamfering the teeth and shaving. Chamfering is carried out at a cutting speed of 28 m/min, the cycle time being 111 sec, of which the machining time is 85 sec. Shaving is accomplished with a cutting speed of 40 m/min, with feeds of 0·255 and 0·04 mm/rev. The cycle time is 113 sec, of which the machining time is 77 sec. This operation is followed by washing and inspection outside the automatic line.

As already mentioned, inspection operations are effected outside the automatic cycle, as distinct from normal practice in similar lines for the automatic machining of gears in other countries, because Russia, apparently, cannot as yet produce suitable automatic measuring and inspection equipment.

The same organization has also developed an automatic line for machining double cluster gears. This line is essentially similar to that described above, the main difference being that the teeth are cut on high-output circular-cutter gear generators fitted with multi-cutter heads, which, it is hoped, will increase the output of machines by from 4 to 5 times. In this particular line, the intention is to equip each machine tool with an individual automatic store, thereby enabling the plant to reduce time losses for repairs and tool changes.

Ni Resist
for Corrosion-Resistant Castings



Ni Resist

The high-nickel, austenitic cast irons sold under the trade mark 'Ni Resist' are widely used for corrosion and wear-resisting services.
For use in Chemical works 'Varley' pumps are supplied with 'Ni Resist' bodies and 18/8 chromium nickel stainless steel shafts. Standard grade 'Ni Resist' is used for contact with caustic liquors, ammoniacal solutions, weak acids, petroleum products and agricultural sprays.
The thousands of 'Varley' pumps in successful use are evidence of the value of 'Ni Resist' to the Chemical plant manufacturer and user.

SEND FOR OUR PUBLICATION:
Ni Resist in the Chemical and Allied Industries
Ni Resist is a registered trademark.

THE MOND NICKEL CO LTD

THAMES HOUSE · MILLBANK · LONDON SW1

TGA C135

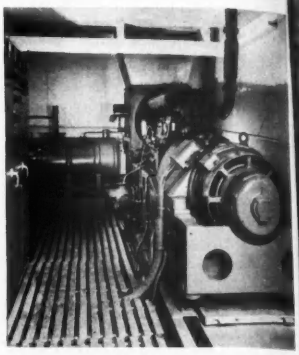
Custom-built Engines

All over the world you will come across Mercedes-Benz diesel engines — on building sites or in industrial plants, in harbour installations, in mining plants or in hospitals.

There are three good reasons for this: Firstly, the Mercedes-Benz engine programme comprises 24 types, with horsepowers ranging from 17 to 3000 b. h. p., so that it meets every power requirement occurring in practice.

Secondly: Mercedes-Benz diesels — water-cooled four stroke designs with precombustion chamber, of vertical or horizontal in-line types or of V arrangement, supercharged or unsupercharged — are as powerful, dependable and durable as all Mercedes-Benz products. And thirdly: At hundreds of service stations scattered all over the world there are skilled mechanics to keep every Mercedes-Benz diesel operating at top performance.

Mercedes-Benz diesels therefore offer all the properties required for economical and reliable operation.



Quality is dependable

Mercedes-Benz diesel engines have many good qualities: They supply a maximum of power for a minimum of fuel; their simple, rugged design makes for easy maintenance, and they will retain their high performance over a long period of years. But their most important advantage is their outstanding quality: This means dependability for every application.

974 MAI

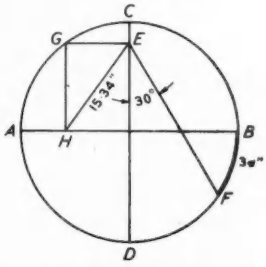
MERCEDES-BENZ DIESEL

CHRISTMAS COMPETITIONS

Prizes of 5 guineas each are offered for the first three all-correct or most nearly correct solutions to the three following problems, none of which is particularly difficult. To give our overseas readers a chance of competing, the closing date is March 1st, 1960, and no entries will be opened until after this date. The name and address of competitors must be filled in on the attached form, and the envelope, addressed to The Engineers' Digest, 120 Wigmore Street, London, W.1, must be marked "Competition" in the top left-hand corner.

(1) THE PROBLEM OF THE RED HERRINGS

A fishmonger has a circular slab, of which *AB* and *CD* are diameters at right angles to one another. On the slab is displayed a red herring *EF*, lying at an angle of 30 deg. to the diameter *CD*, the length of the arc *BF* being 3π in. *EG* is another herring, which lies parallel to *AB*, while herring *GH* lies parallel to diameter *CD*. The herring *HE* measures 15·34 in. in length.

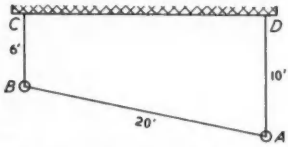


From this admittedly unusual way of displaying fish, can you deduce (to two decimal places) the diameter of the fishmonger's slab? (The value of π should be taken as 3·142)

(2) THE PROBLEM OF THE LAZY CARETAKER

In our office-block, the caretaker who looks after the heating system usually sits at his desk *A*, which is 10 ft from the edge of a coal-bunker *CD*. At regular intervals, he picks up his shovel, which he keeps within reach of his desk, takes a shovelful of coal from the bunker, and replenishes the furnace *B*, which is 6 ft from the edge of the bunker and 20 ft from his desk.

Now, our caretaker, who is rather lazy, on one occasion decided that, the next time he had to throw a shovelful of coal on the fire, he would walk the shortest possible total distance from his desk to the



bunker and back from the bunker to the furnace. Can you indicate his shortest possible route and say how long it is (to one decimal place)?

(3) THE PROBLEM OF THE GENERATOR AND ITS TURBINE

After being in service for some time in a power station, a steam turbine had to be provided with a new generator. The turbine is now $2\frac{1}{2}$ times as old as the new generator was when the turbine was as old as the generator is. When the generator is as old as the turbine is now, the combined ages of the generator and turbine will then be 24 years plus the present age of the generator. What are their respective ages now?

(*Now try our Crossword overleaf*)

(Please use block letters)

Name .....

Address of Firm.....

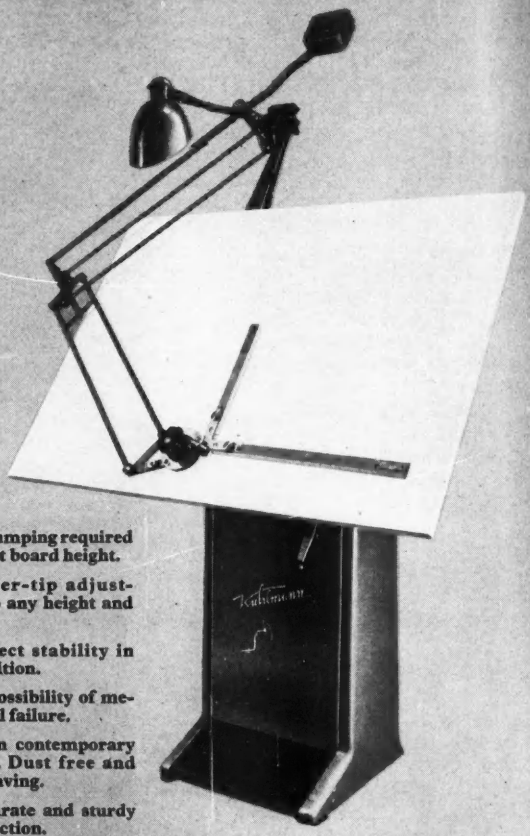
.....

.....

New

KUHLMANN

pedestal type drafting table



★ **No pumping required to adjust board height.**

★ **Finger-tip adjustment to any height and angle.**

★ **Perfect stability in any position.**

★ **No possibility of mechanical failure.**

★ **Clean contemporary design. Dust free and space saving.**

★ **Accurate and sturdy construction.**

Beautifully designed, functionally and technically perfect in every detail, this new pedestal unit gives more freedom and assistance to the draughtsman than ever before.

This unit adds to the many advantages of pedestal units, an infinitely variable height adjustment without slow and often awkward pumping. The potential hazards of faulty hydraulic control have been eliminated.

This new pedestal unit is yet another example of Kuhlmann quality, design and precision.

OZALID COMPANY LIMITED · LOUGHTON · ESSEX

CRYPTIC CROSSWORD

Readers are invited to send in solutions to the following crossword, in which all or nearly all the answers comprise well-known technical words or expressions. Prizes of 5 guineas each are offered for the first three correct solutions opened after the closing date of March 1st, 1960. The name and address of all competitors must be filled in on the attached form, and the envelope, addressed to The Engineers' Digest, 120 Wigmore Street, London, W.1, must be marked "Crossword" in the top left-hand corner.

ACROSS

1 Not an agricultural machine, though 90% of it will yield more crops. (10)

6 Applications held in meritorious esteem. (4)

9 Far-sighted approach to the problem of fitting one tube into another. (10)

10 Exhaust-pipe for an aircraft? (4)

12 A seaside structure evidently worth looking at. (4)

13 Steelyard (for light applications?) (5–4)

15 Not really a measure of wood. (3, 5)

16 Positively very light, though it is for a heavy weight. (6)

18 Mix a variety of tar in a mould. (6)

20 Mixed? O no! O yes! (8)

23 Latin poet with possibilities. (9)

24 Stacking without any musical accompaniment. (4)

26 Characteristic contour found in the Po valley. (4)

27 Electrical disinclination. (10)

28 Among many others, wood, petrol, and kerosene can be used for this. (4)

29 A friend attaches himself to the end of 11 dn. (10)

DOWN

1 Incisions. (4)

2 Making flour in the machine shop? (7)

3 Confine charged particles. (12)

4 Slow Dept. for joining metals (4–4)

5 Start with $x = 0, y = 0$ (6)

7 The sun over the opening provides the solution. (7)

8 Gas port which can be set in metal. (5, 5)

11 The Royal Marines keep still about nothing, but are evidently under control. (12)

14 A mine-motor should be. (5–4)

17 Another example of 28 ac. (4–4)

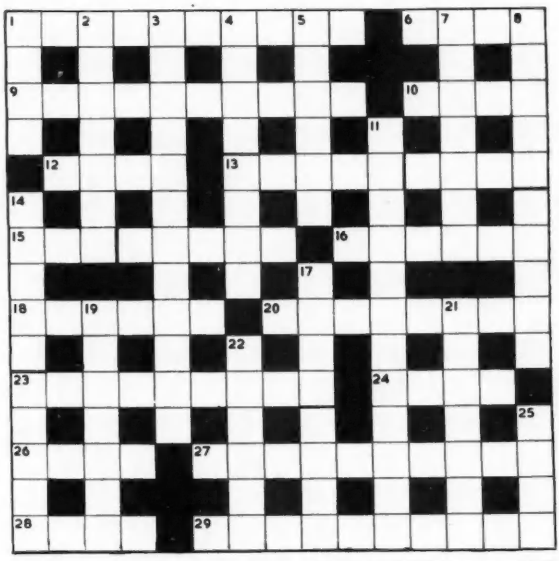
19 If you want to determine the amount in solution, treat it. (7)

21 Nickel alloy produced, strangely enough, by the Linen Co. (7)

22 Noiseless inlets. (6)

25 When deprived of it, levity can be a costly matter. (4)

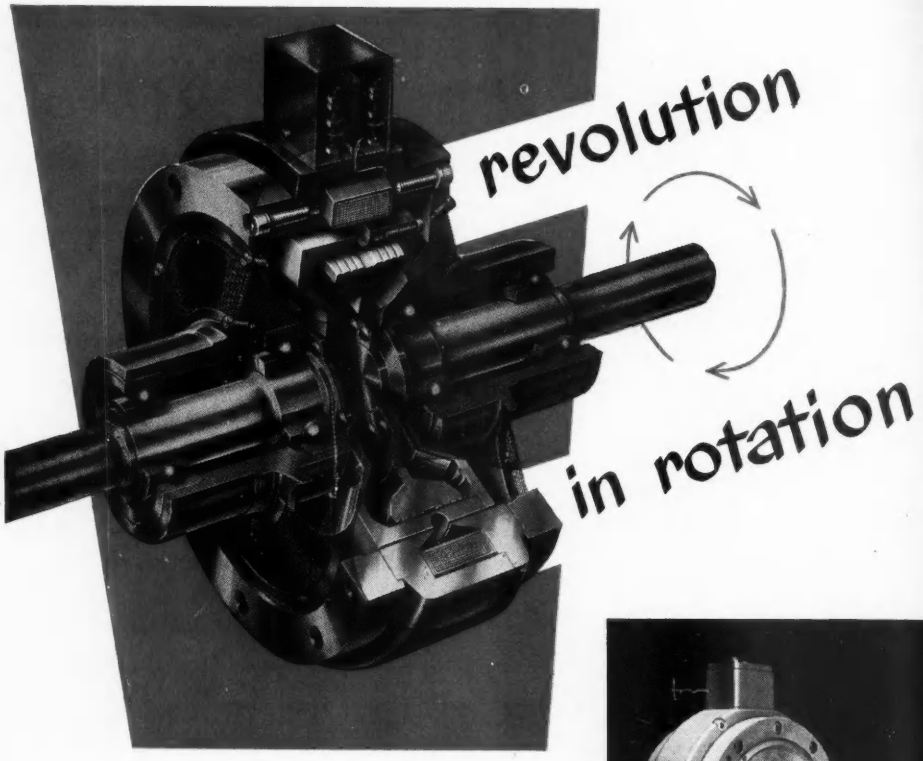
(*Have you tried our competition on page 511?*)



Name .....

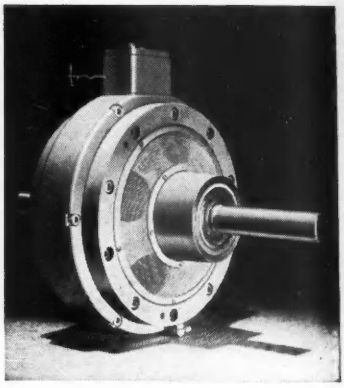
Address of Firm .....

.....



SMITHS
Magnetic Particle COUPLING

This is a positive coupling working on a new principle. It is NOT a magnetically operated clutch, and there are no plates to wear.



Driving and driven members are coupled by magnetically activated particles, giving perfectly smooth take-up and accurate control of torque. Eight standard units are made ranging from 1/3 to 200 lb/ft.

SMITHS S. SMITH & SONS (ENGLAND) LIMITED

INDUSTRIAL PRODUCTS DEPARTMENT, WITNEY, OXON. Telephone WITNEY 678

AP/85

British Industrial Developments

Rotary Storage and Dispensing Machine for Small Components

A new rotary storage and dispensing machine known as the " Rotasembler ", developed and manufactured by Work Study Equipments, of Woodford Green, Essex, has been introduced at Regentone Radio Television Ltd., of Romford, Essex. This rotary indexing machine stores large quantities of small components and dispenses them in correct assembly sequence to a point only a few inches from the assembly area, eliminating complicated identification of parts by the operator and greatly reducing the amount of space required to store quantities of many types of components. At present, twenty Rotasemblers are in use at Regentone, where they are required to store and dispense small electrical components such as resistors and capacitors used in the production of printed-circuit radio and television receivers. These units replace fixed part layouts of bins arranged around the operators and have already resulted in considerable labour and space savings, with an improvement in efficiency of 40%.

Despite its extreme compactness, the Rotasembler is capable of storing up to 38 different components in 19 hopper units, each of which is vertically divided to form two hoppers, one inside and one outside. The dimensions of the outside hopper are 1½ in. deep, 3 in.wide, and 20 in. high, while those of the inside hopper are 1¼ in. deep, 3 in. wide, and 24 in. high, each hopper being capable of storing as many as 2000 small components. The feed-lip of the outside hopper is located above the feed-lip of the inside hopper and both are fitted with an adjustable gate which controls the flow of components to the feed-lips. The dividing plate between each hopper protrudes above the level of the top of the double hopper unit to facilitate easy filling and to provide space for identification of the rear components. The hoppers are easily removable and allow ease of access to the simple indexing mechanism located within the circle of hoppers. The hoppers are mounted on two support rings attached to a centre shaft driven by the indexing mechanism, which comprises a chain-driven ratchet gear operated by a double-acting air cylinder and a small brake assembly. A foot-valve controls the movements of the air cylinder and brake, controlling in turn the indexing movements of the hoppers.

Among the advantages achieved by the use of the Rotasembler are almost total elimination of assembly errors, as the operator is presented with a single and habitual path of travel for each component, and identification of components is made almost unnecessary. These factors combine to produce a regular and rhythmical operating sequence which reduces operator fatigue and speeds up assembly. It has been estimated that approximately 2000 components per hour can be assembled by one operator using a Rotasembler, more than doubling the previous production rate. Furthermore, each hopper can store up to six times more components than any other storage assembly systems in current use.

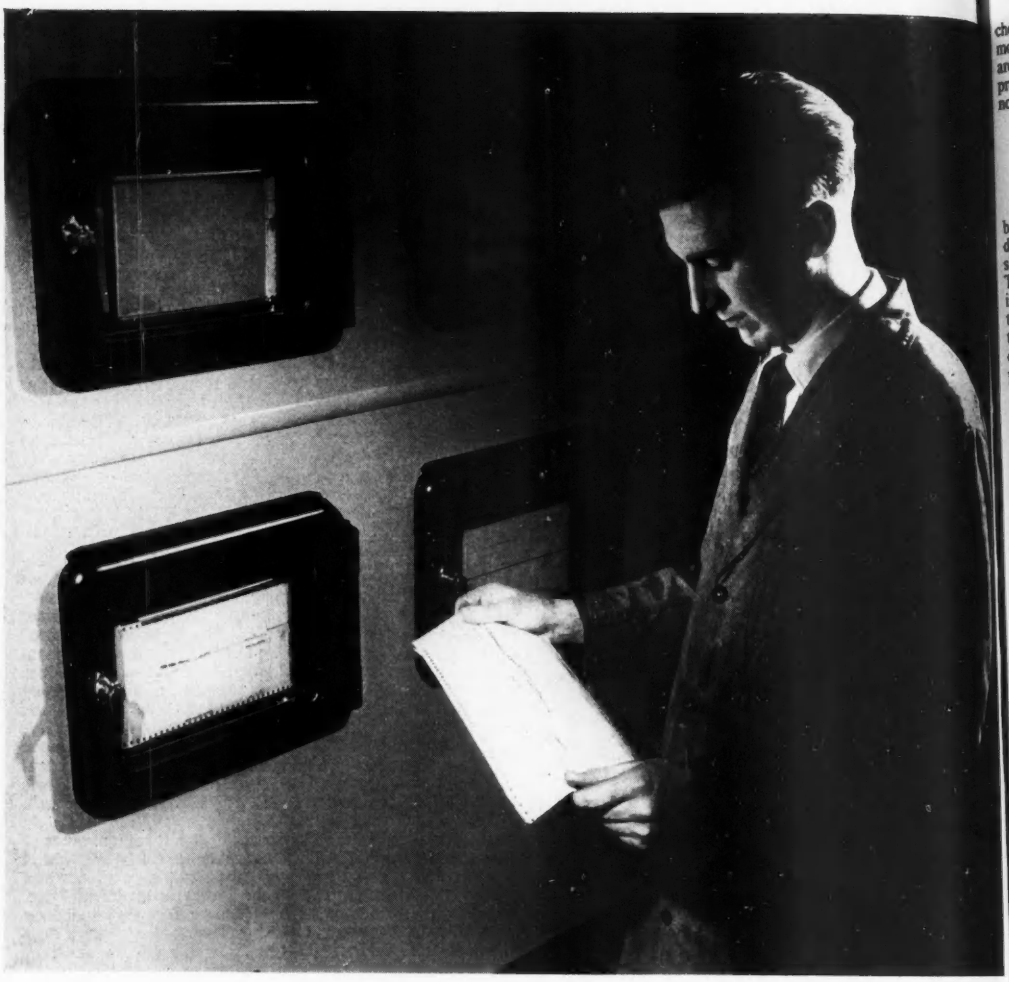
Centrifugal Metal-Finishing Process

Stated to improve the finish of metal parts by processing them in loose abrasives in a manner quite different from conventional barrel-finishing, the " Harperizer " machine, recently developed in the U.S.A. by the Harper Buffing Machine Company, and now to be manufactured in the U.K. by W. Canning & Co. Ltd., of Birmingham 18, incorporates innovations which drastically reduce processing times and make it possible to finish intricately contoured parts. The machine is built to produce a high centrifugal force which holds the parts and the abrasive media together in a tight mass, but causes them to move with relation to each other. As a result, material removal is rapid, and certain types of intricately contoured parts can be uniformly smoothed to a finish comparable with that produced by buffing.

Essentially, the " Harperizer " consists of a number of containers mounted on a large turret which revolves at speeds sufficiently rapid to subject the workpieces and media to from 40 to 50 *g* as a result of centrifugal force. The containers are so mounted that they are rotated on their own axes while the turret is revolving. Each container is 37 in. in length and has an inside diameter of 11 in., removable dividers forming compartments to make it possible to process products of different sizes. All containers are fitted with resilient neoprene linings.

As rotation of the turret commences, centrifugal force gradually increases until the turret reaches normal speed, compacting the medium and pressing it against the sides of the container and against the parts being processed. Since, however, the container is rubber-lined, the abrasive media do not slide against the sides, but tend to creep with a characteristic caterpillar-like motion around the inner wall of the container. The combined result of the high centrifugal force and this characteristic motion is that the parts are held tightly within the abrasive mass, with the abrasives gradually sliding against their surfaces, removing metal and refining the finish.

Materials are kept compacted at all times, " waterfalling " being avoided and falling or actual bombardment of the workpieces with abrasives being eliminated. In addition, since the containers themselves are rotating, the position of greatest centrifugal force and the centre of stability constantly shift within the container, so that all surfaces of components are subjected to approximately the same action, while the sustained high pressure and slow movement of the work and abrasives cause the abrasives to abrade all surfaces to a uniform depth. Both wet and dry abrasive media can be used, but the medium



He reads it easily

A clear record of the last two shifts—and the pen already beginning its course on the next chart. In his hand he has the past: on the panel is the present.

Arkon Recorders measure gas and air flow, pressure or vacuum, or pressure and vacuum: flows in one inch pipe or 36 inch mains, pressure or vacuum from 0.1 inches water gauge to 50 lb. per square inch. They give a clear, unmistakable record which you can read like a book, without hesitation and without mistakes. You can leave the chart on for a few hours, a day, or a week—the record will always be there. Easily read, easy to look after, robust enough to stand on the job, Arkon Instruments can help the control of any process—and their accuracy will satisfy even the men in the lab.

More about them in pamphlet AB/24

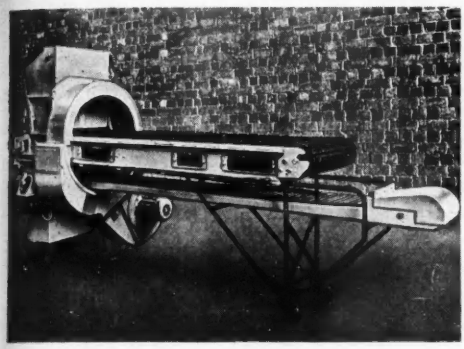
WALKER, CROSWELLER & CO. LTD., CHELTENHAM

Telephone:CHELTENHAM 56317

chosen should be fine enough to conform closely to the most intricate contours of the workpiece. Wet operations are successful in deburring and radiusing edges and in processing parts which are too small or too light for normal tumbling operations.

Automatic Chain-Grate Ash Extractor

The new automatic ash extractor recently introduced by Riley (IC) Products Ltd., of London, W.C.1, has been developed as a standard item for installation with most sizes of new or existing Riley type-T chain-grate stokers. The advantage of an automatic ash extractor of this kind is that it eliminates frequent opening of ash doors and thus prevents ingress of air, with consequent cooling of the furnace gases and reduction in efficiency. Forced-draught fans do not have to be stopped while ashing is in progress, and there is, of course, a great saving in labour.



The extractor is of the conveyor type and is so designed that there is very limited wear on moving parts, since the ash is stationary on the apron plates and moves in relation to the conveyor, not in opposition to it, as in the case of scraper and drag link conveyors. The conveyor travels at a constant speed of $3\frac{1}{8}$ ipm, and is driven by a separate gear assembly comprising a $\frac{1}{8}$-hp motor with reduction gear and a further gear-train with a 3:1 reduction, giving a front-shaft speed of 0·32 rpm. A spring-loaded clutch, with the driven half on a splined shaft, protects the gear assembly from overload. Provision is made for tensioning the conveyor.

A steam cleaning assembly, operated for about 15 sec per week and using less than one pound of steam in the process, is incorporated to remove any fine particles of ash which penetrate to the inside of the extractor. The ash box at the front of the stoker provides for an ash chute to a water-trough conveyor, but can be fitted with a draw-plate for discharging ash into a low trolley or pan with runners attached.

Metallurgical Powder Dispenser

Slag-making fluxes, alloying elements, and structure-controlling additions are generally added to the surface of molten baths, usually resulting in slow rates of reaction, poor chemical efficiency, or low recovery of the added elements. It is now reported, however, that these difficulties can be completely overcome by means of a new metallurgical powder dispenser, produced by British Oxygen Gases, Limited, of London, S.W.1, which enables a range of powders and metals to be added under the surface of a melt.

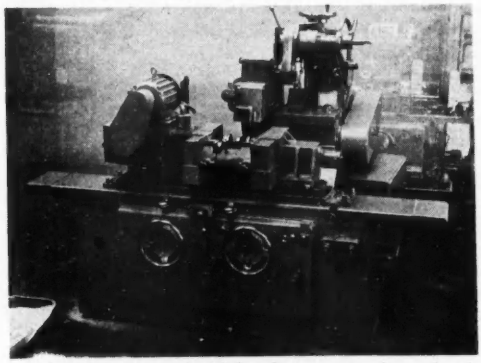
In the treatment of cast iron, both calcium carbide and graphite can be injected with the dispenser into the molten metal, using a stream of nitrogen and an electrographite lance. Calcium carbide is used as a desulphurizer and an addition of 1%, made at a metal temperature of 1400°C, halves the sulphur content at any level. Graphite is added as a recarburizer and inoculant, and gives a remarkably high recovery. The treatment can be carried out in suitable covered ladles, receivers, or induction furnaces.

One of the outstanding successes of the new technique has been the injection of mixtures of calcium carbide and graphite into iron melted from a high proportion of steel scrap. Normally, such iron has a high sulphur content and a low carbon content. Not only can the composition be corrected by the carbide-graphite mixture, but a practice can be established which effects substantial economy in metallic-mixture costs.

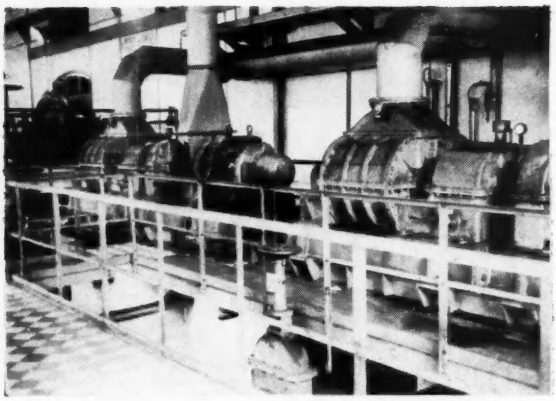
Current practical investigations in selected iron foundries and alloy steelworks indicate that the new powder dispenser may have a much wider field of application. Thus, the introduction of desulphurizing and inoculating agents, either separately or together, should increase the scope of dispensing techniques in the manufacture of ductile iron. Other interesting applications are in electric-furnace steelmaking for the introduction of lime for desulphurizing and also certain ferro-alloys. The dispenser, which is robustly designed for service in foundries and melting shops, has a capacity of 150 lb of carbide or 100 lb of graphite. These powders can be dispensed at up to 30 lb per minute, with a nitrogen consumption of as little as 0·5 cu ft per pound of material added.

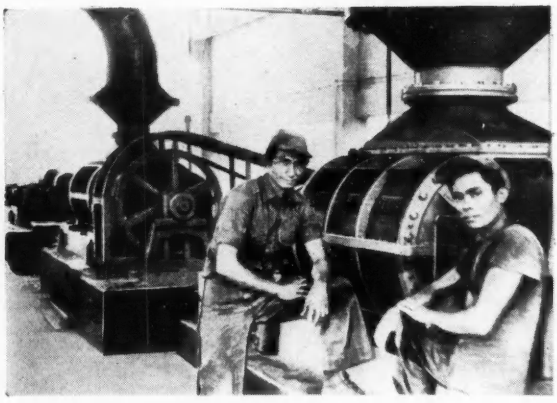
Small-Capacity Crankpin-Grinding Machine

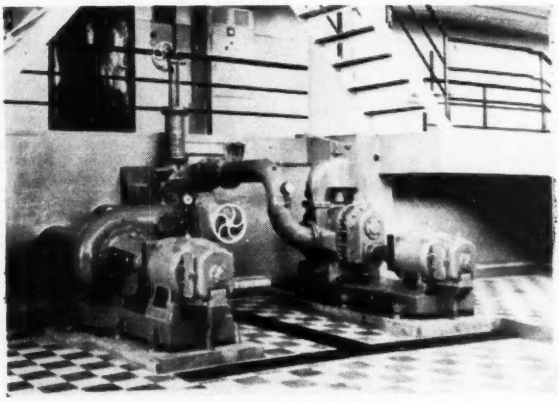
As announced by Newall Group Sales Ltd., of Peterborough, the Newall-Keighley model L12C small-capacity crankpin-grinding machine introduced by Keighley Grinders Ltd., one of the Newall Group of companies, is fundamentally a standard cylindrical grinder with a 12-in. swing, fitted with a special headstock and tailstock fixture which can be removed as a unit from the top table and replaced by a conventional workhead and tailstock for plunge-cut and traverse grinding. The machine, which is designed for the production of single- and double-throw cranks, is available in two sizes, both accepting crankshafts which can be swung within a radius of $4\frac{1}{4}$ in., the smaller size accommodating shafts up to 16 in. in length, and the large size up to 20 in. in length.



The complete work-driving fixture comprises a headstock and tailstock, with attendant throw-blocks and a geared transmission unit to provide a double-ended drive. The workhead motor is automatically started and stopped with advance or retraction of the wheelhead, and a cam controller is incorporated to halt the motor so that the throw blocks are in the loading position; for gauging purposes, an alternative stopping position is obtained by operation of an "inching" button. The drive to the







ABOVE: LYONS LA MOUCHE GASWORKS, FRANCE. Two ROOTS-HIBON gas compressors, type HL 320, capacity of each unit 3,500 c.f.m. uncleaned town gas. **CEBU, PHILIPPINE ISLANDS.** Two ROOTS-HIBON gas compressors, capacity of each unit 7,000 c.f.m. of dry, sulphurous gas. **CASABLANCA, MOROCCO.** Three ROOTS-HIBON sets, type P.58, in a water purifying station.

"ROOTS" PUMPS

50 years' experience

—International references

ROOTS-HIBON Compressor-Exhausters are distinguished by their advanced design, simple and robust construction, small power requirement per cu. ft. of gas, high efficiency, minimum wear, maintenance and oil consumption.
ROOTS-HIBON Compressor-Exhausters are manufactured in single and two-stages (twin) types. Maximum pressures and vacua delivered are as follows : single-stage, 14 p.s.i. pressure, $15\frac{3}{4}$" Hg. vacuum ; two-stage, 28 p.s.i. pressure. 28" Hg. vacuum.
ROOTS experts are available for consultation on all ROOTS problems

The POMPES HIBON *manufacturing programme also includes:*

- *Vacuum pumps and Liquid-ring Compressors.*
- *Rotary Pumps for fluid and viscous media.*
- *Rotary Vacuum Pumps.*
- *Centrifugal Pumps with horizontal and vertical spindles.*

"HIBON have a solution for every pumping problem."
Please request illustrated litérature.

Pompes HIBON

Établissements G. HIBON - ROUBAIX (FRANCE) : 2, rue des Vosges
Sté Belge des Pompes HIBON - BRUSSELS (BELGIUM) : 123, Av. Eisenhower

tailstock is through gears, split and sprung to eliminate backlash, by means of a shaft running in grease-packed taper roller bearings. To facilitate disengagement when necessary, an eccentric gear is fitted to the tailstock intermediate drive. The fixture also incorporates a built-in device for locating the crankpin diameter in the correct position for grinding.

Consideration given to the importance of maintaining accurate wheel form for the type of work entailed has resulted in the development of a novel and highly efficient wheel-dresser/former assembly. This wheelhead-mounted unit houses a diamond, which is hydraulically traversed for dressing the wheel face, and a motor-driven crusher on the same mounting for forming the radii. Engagement of diamond or crusher is obtained by means of a manually applied plunger which operates a feed screw common to both and results in a perfect blending of radii with the wheel face.

Taper-Shank Twist-Drills with Replaceable Flutes

An interesting innovation in the field of twist-drill tooling has been introduced by Clarkson (Engineers) Ltd., of Nuneaton, and takes the form of a system of taper-shank drills with replaceable flutes. Designated "TaperFast", the new system brings the accuracy and precision of taper-shank work to the smaller sizes of jobber drills, with the advantage that, when the flutes are broken or irretrievably damaged, a new flute can easily and quickly be fitted, resulting in considerable economy, a speed-up of production, greater accuracy, and the elimination of spoilt work.

The chief advantages of the system over a conventional drill chuck include a greatly reduced overhang, with a consequent increase in rigidity and accuracy, complete visibility of the work and hole, a positive drive from the taper and tang, eliminating snatch and slip and the risk of drill breakage, and a true-running drill, as the accurate taper fits directly into the machine spindle. In addition, the holders are hardened and ground for long life and greater accuracy, and are less likely to damage machine spindles.

Semi-Automatic Welding Equipment for Thin Materials

Designed for the rapid semi-automatic welding of thin ferrous and non-ferrous materials, the new "Sigmette" equipment introduced by Quasi-Arc, Limited, of Bilston, Staffs., is based on the established "Sigma" process, using a continuous coil of bare wire electrode and shielding by argon or carbon dioxide. However, as distinct from the "spray" type of transfer normally associated with Sigma welding, use is made of what is known as the "short-arc" technique, in which metal transfer is in globular form.

With the new equipment, welding of all materials can be carried out in any position, including vertical and overhead, using a portable lightweight welding gun weighing just over 3 lb. A spool carrying either 1 lb of aluminium wire or 2½ lb of ferrous wire is carried in the gun itself and is sufficient to permit welding to be performed for periods up to 45 min. Only the gun needs to be carried to the work, enabling the operator to weld comfortably in confined spaces or in areas remote from power and gas supplies, without having to move heavy equipment.

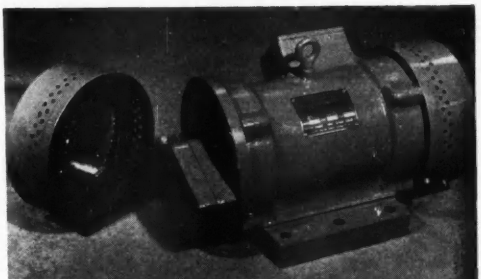
The wire is positioned initially by means of an inching button in the base of the handle of the gun, operation of the trigger starting gas flow and initiating a slow wire feed. As soon as the arc strikes, full wire speed comes into operation and is adjustable by means of a single knob on the voltage control unit, which controls all welding variables, including wire-feed rate and gas flow. Standard 30-ft leads between the control and the gun permit a wide radius of operation.

The gun handles three sizes of wire, i.e., 0·03 in., $\frac{3}{64}$ in., and $\frac{1}{16}$ in., and is continuously rated at 125 A for the 0·03 in. wire and 200 A for the other sizes. A medium-speed wire-feed motor, fitted as standard, gives a wide range of applications to all sizes of wire, but, if required, high-speed or low-speed motors can be supplied for specialized work with 0·03-in. and $\frac{1}{16}$-in. wires. The system therefore enables a complete range of applications to be covered with only one gun. Maintenance of the gun is extremely simple, the only tool required being a screwdriver.

Electric Motors for Vibrating Drives

A new range of electric motors, specially designed for vibrating drives, the first of their kind to be manufactured in the U.K., is being produced and marketed jointly by The English Electric Company Limited, of London, W.C.2, and the Grantham Electrical Engineering Company Limited. These motors can be used wherever a vibrating motion is required, e.g., for driving screening, hopper, and continuous-drying systems, tamping equipment, and machines for breaking or grinding down materials.

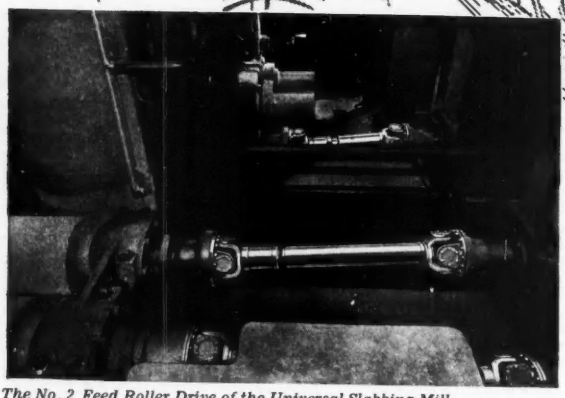
The motor is a completely self-contained unit which provides an inexpensive and reliable drive by eliminating all the mechanical parts associated with an eccentric shaft arrangement. Vibration is generated by out-of-balance weights at either end of the motor, these weights being capable of easy adjustment by single bolts to give the required output. The motor is of robust construction, and incorporates heavy-duty bearings with special features to deal with out-of-balance loads. In fact, tests have shown that these bearings, which are lubricated for life, should be serviceable for many thousands of hours operation. The unit is totally enclosed, dustproof, and weatherproof. The frame is of nodular cast iron, with integral feet, and the shaft is of high-tensile steel, to withstand the high centrifugal forces to which it is subjected.



At present, these motors, which must be mounted on a resilient base, are available in a standard range of powers between ½ and 1½ hp, with synchronous speeds of 1500 or 3000 rpm, for operation from a 3-phase, 50-cps supply of 110 to 650 V. However, greater outputs and other supply frequencies can be provided, if required.

Top Pinch Roll Drive on the No. 2 Coiler, which coils steel strip leaving the Hot Strip Mill at the Abbey Works of The Steel Company of Wales Ltd.

DEPENDABILITY IN INDUSTRY



The No. 2 Feed Roller Drive of the Universal Slabbing Mill at the Abbey Works of The Steel Company of Wales Ltd.

Well known in the Automotive and Railway Industries, Hardy Spicer are now supplying propeller shafts and universal joints in increasing quantities for other engineering applications. Typical of these are the drive shafts and universal joints used at The Steel Company of Wales Ltd. Hardy Spicer's wide experience ensures the highest standards of design and performance. Please write for further details and illustrated leaflets.

HARDY SPICER

PROPELLER SHAFTS

Product of the Birfield Group

HARDY SPICER LIMITED

CHESTER ROAD · ERDINGTON · BIRMINGHAM 24 · TELEPHONE: ERDINGTON 2191 (18 LINES)

Engineering Division of BIRFIELD INDUSTRIES LIMITED, Stratford House, W.1

ADDITIONAL ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

Flash Evaporators for the Distillation of Sea-Water.
By A. FRANKEL. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, December 9, 1959, 16 pages, 23 illustrations)

IN recent years there has been a considerable increase of interest in the conversion of saline waters, and particularly of sea-water, into potable water. Active research into various methods of desalting water is proceeding in a number of countries, and a fair proportion of this effort is devoted to improving the economics and the performance of sea-water evaporating plant.

In this paper, the thermodynamic principles on which the flash evaporator operates are described, and some of the reasons for the recent emergence of this type of distillation plant are explained. It is shown that the performance of a flash evaporator is much less dependent on the number of stages used than that of a submerged-coil unit. The thermodynamic losses involved in using a finite number of stages, and the effects of other losses which are unavoidable in practice, are described and assessed.

The actual designs of evaporator vessels are also described, showing means of avoiding interstage piping or ducting, despite the use of a large number of stages. In addition, reference is made to two large-size test rigs built to confirm the basic ideas underlying the development. One was devoted to the exploration of deposition problems and the measurement of heat-transfer data, while the other test rig was used to develop various methods of separating moisture from the vapour produced in the evaporator, and to investigate the flashing-off process. Some of the test results achieved on these rigs are also included.

Magnetic Domains in Cementite.
By M. HILLERT and N. LANGE. (From *Jernkontorets Annaler, Sweden*, Vol. 143, No. 7, 1959, pp. 414–425, 14 illustrations)

SOME years ago, it was noticed that cementite (Fe_3C) displays a zebra-striped pattern when examined in polarized light with crossed polars. The same observation was recently made by the present authors, and a closer examination of cementite of different origin was undertaken. Some of the patterns observed are presented in this report, and evidence is given that they represent the ferromagnetic domain structure of cementite.

Cementite displays a zebra-striped pattern when examined in polarized light with crossed polars. This pattern has been observed in cementite of different origin and is independent of the mechanism of formation of the cementite. As a rule, the patterns in neighbouring grains were observed to be continuous at the grain boundaries, i.e., the dark stripes in one grain meet with dark stripes in the neighbouring grain. This rule seemed to hold even when the two grains had very different orientations, though one exception was observed in this investigation, where the bright stripes in one grain appeared to continue as dark stripes in the neighbouring grain. More complicated patterns were also quite common, and even these patterns were found in many cases to be continuous at the grain boundaries.

In the simplest case, the pattern can be described as alternating bright and dark stripes. It was observed that the dark stripes may grow bright and the bright stripes dark if the polars are in the crossed position and the cementite crystal is rotated, or if the crystal is fixed and one of the polars is slightly rotated about the crossed position.

A final proof of the magnetic nature of the pattern was obtained by mounting a thin specimen in the gap of an electromagnet and studying it in a microscope. One of the sets of stripes disappeared as the specimen was magnetized and returned in a new pattern when the magnetic field was again decreased. For every half-cycle of magnetization, the north and south poles exchanged their sites, as was to be expected on theoretical grounds. The magnetic hysteresis of the specimen could be studied by comparing the total amount of one kind of pole when the magnetic field was increasing and decreasing.

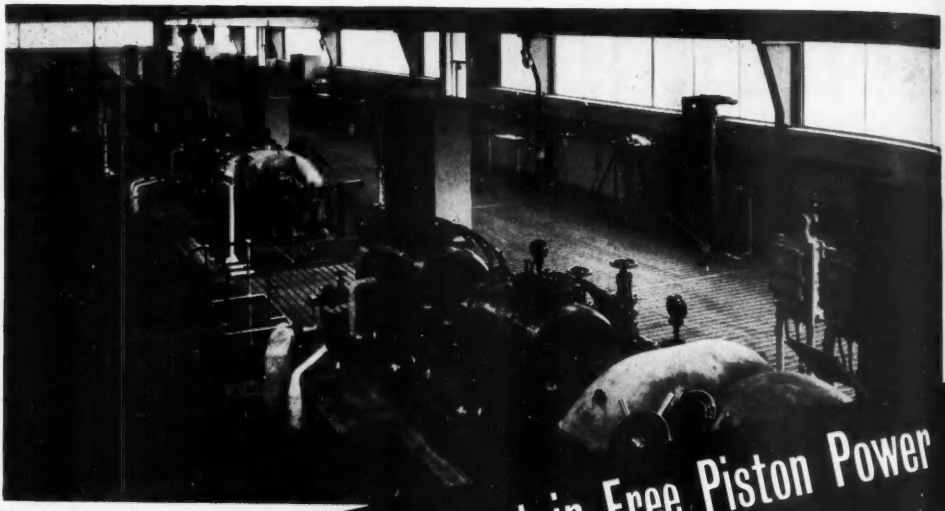
It appears that the patterns observed in cementite crystals may provide a valuable metallographic tool. It is possible, for instance, that the orientation of the crystalline axes can be evaluated from the type of pattern displayed by a crystal and from the main direction of this pattern. One example is presented in which a grain-boundary crystal of cementite and the adjoining Widmanstätten plates have the same brightness, the same pattern, and the same direction of the pattern. This strongly suggests that the Widmanstätten plates in this case have, contrary to normal expectations, developed from the grain-boundary cementite.

Application of Boundary-Layer Theory to Explain Some Nozzle- and Venturi-Flow Peculiarities.
By G. W. HALL. (From an advance copy of a paper received from *The Institution of Mechanical Engineers, London*, October 1959, 8 pages, 7 illustrations)

IN the development and testing of certain engineering products, accurate measurement of fluid flow through closed conduits is of vital importance. Much of this flow metering is effected by means of pressure-difference devices of the nozzle and Venturi types, the geometries of which have been standardized in the various national Flow-Measurement Codes. With the aid of these codes, the need for calibration of the devices should be eliminated, since the flow rate is intended to be predictable to within specified tolerances. On the face of it, this state of affairs appears to be eminently satisfactory. Unfortunately, cases arise where the Flow-Measurement Code fails to predict correctly the observed rate of flow. No explanations have been available for these recurring discrepancies, principally because there is as yet no comprehensive explanation of the physical mechanism behind the flow through such area constrictions.

This paper gives, in outline, an analytical treatment of the flow through a certain class of closed-conduit flowmeter area constrictions and is intended as an initial contribution towards a comprehensive solution of the problem. The theory is put forward that laminar-turbulent boundary-layer transition within the throat of a nozzle or Venturi is the cause of certain peculiarities observed in flowmeter calibrations, particularly in the range of throat Reynolds numbers from 10^5 to 10^6. These peculiarities include widely different discharge-coefficient values for constrictions that are apparently manufactured to the same specification, and difficulty in securing repeatability of results, even for the same constriction.

That the flow as a whole is being accelerated through the constriction makes the hypothesis at first sight difficult to support, since in such circumstances boundary-layer transistion is normally delayed to Reynolds numbers well in excess of 10^6. Examination of the constriction-wall longitudinal-pressure distribution, however, reveals a local pressure rise towards the downstream end of the area contraction, at least for most standard designs. Associ-



Photograph by kind permission of I.C.I. Ltd.

An Outstanding Achievement in Free Piston Power

Hawker Siddeley Brush Turbines Limited are pleased to announce that the Brush Gas Expansion Turbines in the new No. 3 Olefine Plant of Imperial Chemical Industries Limited are now in operation.

This, the world's largest Free Piston Plant, incorporates six Gas Expansion Turbines totalling 16,000 h.p. and is the first application of Free Piston power to a Chemical Plant.

HAWKER SIDDELEY BRUSH TURBINES LTD.

HUCCLECOTE, GLOUCESTER

TELEPHONE: GLOUCESTER 67031

TELEGRAMS: TURBINES GLOUCESTER. TELEX

A Member of the Hawker Siddeley G oup

ated with this pressure rise is a region of decelerating flow just outside the boundary layer, which is probably the principal cause of a relatively early onset of transition to turbulent flow within the boundary layer. The hypothesis thus appears reasonable.

In order to avoid calibration peculiarities, it would seem essential to introduce some positive form of boundary-layer control, as, without this, changes in such factors as flow disturbance at constriction entry, boundary roughness, vibration, etc., may, through the agency of variations in the boundary-layer transition conditions, markedly affect the value of the discharge coefficient.

The analysis shows, incidentally, that there is really no basis for the apparently widespread belief that nozzle and Venturi discharge coefficients inevitably settle down to a constant value for all Reynolds numbers exceeding a certain " critical " value.

Effects of Sound-Reduction Devices on a Turbulent Jet.
By G. M. Corcos. (From *Journal of the Aero/Space Sciences, U.S.A.*, Vol. 26, No. 11, November 1959, pp. 717–722, 18 illustrations)

It has been established that the major part of the noise generated by jet engines originates in the mixing of the high-velocity exhaust gases with the air surrounding the jet. This mixing is turbulent and characterized by large velocity fluctuations and consequently by pressure fluctuations which in part propagate or radiate away from the jet. The magnitude of the pressure fluctuations in the jet is related to the magnitude of the velocity fluctuations there, and the extent to which these pressure fluctuations propagate away depends on their frequency or time scale.

In this paper, an account is given of an attempt to explain in simple terms how ejectors, corrugated nozzles, and multiple nozzles modify the turbulent mixing of a jet so as to generate less aerodynamic noise. Simple analytic and dimensional considerations lead to the conclusion that the noise reduction is due primarily to a decrease in turbulence levels in the mixing region. It is suggested that this is accomplished by accelerating the ambient air through a longitudinal pressure gradient before mixing it with the jet. Thus, a sheath of flowing air decreases the lateral jump in the mean axial velocity responsible for the turbulence level in the mixing region. An experiment at low speed with an ejector and a corrugated nozzle is reported, and mean velocity profiles and turbulent surveys have been obtained. The results are in good agreement with expectations and provide strong support for the hypothesis.

Orbits of Artificial Satellites.
By W. T. Thomson. (From *Journal of the British Interplanetary Society, London*, Vol. 17, Nos. 3–4, 1959, pp. 83–87, 7 illustrations)

Recent technological developments in the fields of rocket propulsion and guidance have made possible the launching of artificial satellites into one of the many possible space orbits. Once a body has been put into an orbit beyond the influence of the atmosphere, its total energy remains constant and equal to that at rocket burnout, the total energy establishing the class of orbit, which may vary from an ellipse to a hyperbola, the circle and parabola being limiting cases. However, an infinite number of orbits of the same class is possible for a given total energy at a specified point in space, and the heading angle of the velocity vector at rocket burnout must specify the particular orbit from the many possible orbits passing through this point.

A study of general motion under an inverse-square central force shows that the orbits of artificial satellites can be specified by three non-dimensional parameters at rocket burnout, these parameters being r_0/R, $r_0v_0^2/\mu$, and β_0, where r_0 is the rocket burnout distance, R the radius of the earth, v_0 the velocity at rocket burnout, β_0 the heading angle at rocket burnout, measured from the normal to r_0, and $\mu = g_0R^2$, g_0 being the acceleration due to gravity at the surface of the earth. The author, who is Professor of Engineering at the University of California, Los Angeles, discusses the conditions for circular, elliptical, parabolic, and hyperbolic orbits, and derives expressions giving the periods of closed orbits in terms of these parameters.

A circular orbit is possible only under the condition where $\beta_0 = 0$ and $r_0v_0^2/\mu = 1$. With $\beta_0 = 0$ and $r_0v_0^2/\mu \neq 1$, the orbit is elliptical, with the launch point corresponding to apogee if $0 < r_0v_0^2/\mu < 1$, or corresponding to perigee if $1 < r_0v_0^2/\mu < 2$. With $\beta_0 = 0$, the orbit is a parabola, with the launch point corresponding to perigee if $r_0v_0^2/\mu = 2$, and a hyperbola, with the launch point corresponding to perigee if $r_0v_0^2/\mu > 2$.

For the general cases where $\beta_0 \neq 0$, the orbit is elliptical for $0 < r_0v_0^2/\mu < 2$, parabolic for $r_0v_0^2/\mu = 0$, and hyperbolic for $r_0v_0^2/\mu > 2$. Where $\beta_0 \neq 0$, elliptic orbits of large eccentricity are possible in the case of large values of β_0.

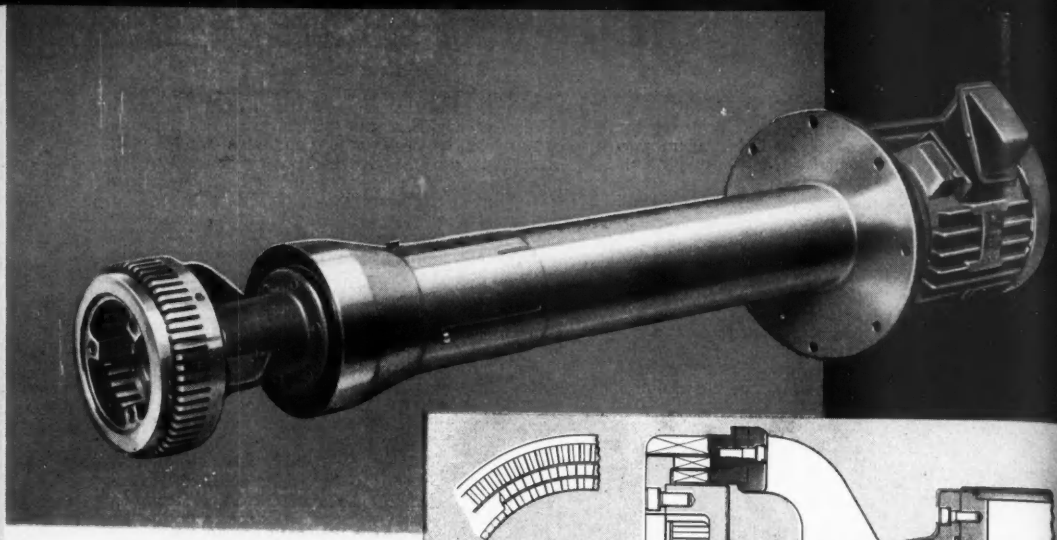
Design and Construction of Power-Station Feed-Heaters.
By J. V. Bigg. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, December 9, 1959, 21 pages, 29 illustrations)

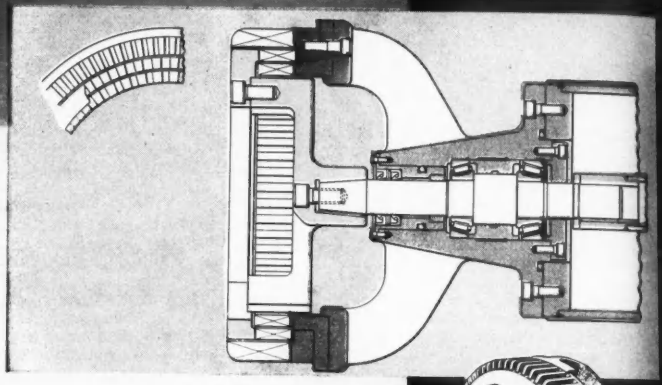
Presenting a survey of various aspects of the design and construction of feed-heaters for modern steam-turbine cycles, this paper first discusses a method whereby the optimum economic size of the individual feed-heater can be investigated, and then considers the thermal design of the heater nest and the pattern of temperature difference introduced by the advent of heaters containing desuperheating and drain-cooling sections, indicating several methods by which such sections can be arranged in a feed-heater nest.

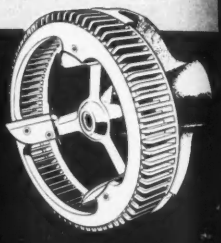
The paper also deals with particular aspects of detail construction, discussing the choice of tube materials and their safe working stresses, and examining the problem of producing a satisfactory roller-expanded tube to tube-plate joint. Methods are given for the consistent production of this joint, together with an account of development work on means of evaluating the soundness of expanded joints by non-destructive methods and by tube pull-out tests. In addition, a description is given of the investigations which have led to the introduction of welded tube to tube-plate joints with both ferrous and non-ferrous metals, and information is presented regarding the amount of torque necessary to achieve desired loadings in heavy bolted constructions and the problem of obtaining uniform bolt loading. Finally, a method of investigation is described which enables the resilience of compressed asbestos jointing to be examined when subjected to a cycle of loading, including heating, simulating working conditions as closely as possible.

Bearing in mind that current thinking on steam-turbine cycles in which feed-heaters are incorporated leads to increasing temperature and pressure conditions under which high-pressure heaters particularly will have to operate, it is concluded that the necessity for a more reliable tube to tube-plate joint under such conditions will undoubtedly lead to the more universal use of the welded joint, together with the development of more highly mechanized means of manufacture for such joints. It is also considered that the trend in header design will lead to some form of diaphragm closure, with a flexible member for sealing, transmitting the hydraulic pressure load to a cover-plate which is used only for load-carrying purposes.

In view of increasing shell-side operating conditions, the shell to tube-plate joint is now a matter of some concern. Because of statutory and maintenance requirements, this must at present be dismantled to permit regular inspection; however, if this requirement were waived, it is considered that there is a very good case for the introduction of a welded connection between the head and the shell, such as has been found satisfactory in service by transatlantic manufacturers.







THE WILLEMS INDUSTRIAL TYPE DISPERSITRON

Regd. Trade Mark

This machine was evolved by Prof. Ing. P. Willems of Switzerland and is manufactured by George Scott & Son (London) Ltd. of Leven, Fife, Scotland. Its action is based upon the combined results of high frequency shock and impact, producing wave frequencies in both the sonic and supersonic range, within the material itself.

It is said in relation to this machine that by suitable design different effects may be produced in varying proportions and that a high throughput is obtained while maintaining high quality. The machine is used in the making of suspensions, stable emulsions and colloid solutions and in the aggregation of gases, liquids and solids, or mixtures of all three, and also in the handling of sticky materials.

It is also claimed that the action is such that emulsions can be produced with reduced quantities of emulsifier and that suspensions can be made with particle sizes in the micron and sub-micron ranges, all these operations being carried out with a saving of process time. The section shows the two toothed stators and the toothed rotor, material having access between the three arms as it flows out radially. The small line drawing shows the principle reduced to its basic elements.

A 10" unit is shown in the drawing. This runs at speeds up to 1500 r.p.m., the spindle being mounted on Timken tapered roller bearings.

A 6" unit is shown in the photograph and runs at speeds up to 3000 r.p.m.

British Timken, Duston, Northampton, Division of The Timken Roller Bearing Company. Timken bearings manufactured in England, Australia, Canada, France and U.S.A.

TIMKEN®

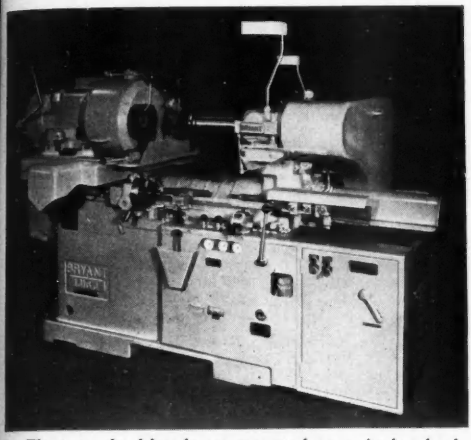
REGISTERED TRADE-MARK

tapered roller bearings

New Materials, Processes, and Equipment

TWO-SPINDLE HYDRAULIC INTERNAL GRINDING MACHINE

Designed to achieve maximum accuracy in combined bore- and face-grinding operations on a wide variety of components, a new two-spindle hydraulic internal grinding machine, designated the 1316-J, has been developed by the Bryant Chucking Grinder Co., of Springfield, Vermont. Two or more operations can be performed on one machine at a single chucking, thereby reducing handling time and enabling the concentricity and squareness of ground surfaces to be held to extremely close tolerances.



The two wheel-heads are mounted on a single wheel-slide, and the work-head, mounted on the cross-slide, is hydraulically indexed to the grinding position for each wheel-head. To increase production, the internal grinding wheel is dressed by a hydraulically operated diamond holder. Closely grouped and conveniently located machine controls can be adjusted to permit either manual or semi-automatic operation. The wheel-slide has a three-point suspension and adjustments which make it possible to keep the wheel-slide and work-slide in perfect alignment, as is essential in precision grinding. The cross-slide moves on four parallel anti-friction bearings, widely spaced to give solid support to the work-table, and responds precisely and smoothly to the slightest movement of the feed-screw. The work-head can be swivelled to grind included angles up to 90 deg., and the machine, which can swing through 16 in., permits the grinding of holes to a depth of 9 in. when equipped with a plain spindle, or 8 in. when equipped with a cam-lock spindle.

SEALED RECHARGEABLE NICKEL-CADMIUM CELLS AND BATTERIES

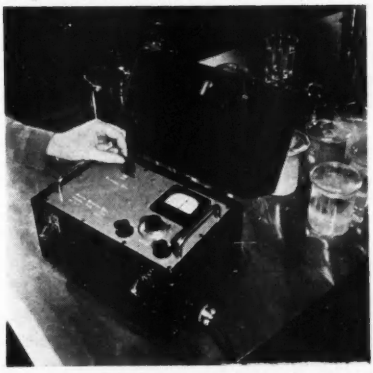
A wide range of compact, sealed rechargeable nickel-cadmium cells and batteries has been introduced by the Burgess Battery Company, Division of Servel, Inc., of Freeport, Illinois. The hermetically sealed construction of these new units eliminates routine maintenance and the addition of liquids, as required by earlier types of nickel-cadmium batteries. Recharging restores these batteries to peak operating efficiency hundreds of times, the response of the cells being equally good to either a slow or a fast charge. Furthermore, they are not affected adversely by long idle periods, either in the charged or uncharged state, and operate satisfactorily at temperatures between 0 and 115°F.

Individual cells are available in eight sizes, together with a range of multiple-cell batteries in numerous voltages. The individual cells, rated at 1·25 V, include six button-type units ranging from 0·4 in. in diameter up to about $1\frac{1}{2}$ in. in diameter. Single-cell batteries in standard miniature " pen-light " and flashlight sizes are also available. All these batteries make use of a special conductive silver-wax inter-cell connection, a dab of the wax on the positive and negative sides of each cell permitting them to be connected in series merely by stacking in a column. The ability of the wax to mould itself to any contour between the cells assures a permanent inter-cell connection which cannot break, even under rough handling.

DENSITOMETER FOR TESTING CLEANLINESS

Developed by the Graham Research Laboratories of the Jones & Laughlin Steel Corporation, of Pittsburgh, Pa., and manufactured under licence by the Branson Ultrasonic Corporation, of Stamford, Conn., the new model CM-1 cleanliness tester now makes it possible to assign numerical values to surface cleanliness in cases where non-bonded soils are involved. As such, its use is indicated in any application where the absence of foreign matter is vital to the success of the operation, such as plating, lithographing, organic coating, and adhesive bonding. Similarly, it can be used in such applications as measuring smut residue after pickling steel, or for evaluation of the detergents and oils used in cold mills, annealing-furnace performance, and the efficiency of electrolytic and alkaline cleaning lines.

Testing is extremely simple and consists of only two steps, i.e., (1) soil is removed from the surface under test with a transparent, pressure-sensitive tape, which is then affixed to a microscope slide, and (2) the optical density of the composite is then measured by the tester, which is actually a specially designed densitometer. The tester has a linear scale from 0 to 1000, the maximum value indicating absolute cleanliness, so that direct readings, giving numerical values of cleanliness, are obtained.



The accuracy of the instrument is stated to be 0·1 %, this being achieved by a ten-turn potentiometer in the balancing circuit, and the testing procedure eliminates the shortcomings of conventional water-break and wipe tests, which merely provide a rough indication of freedom from oils, without offering a means of determining the amount of finely divided soils adhering to a surface.

Flooded with orders?

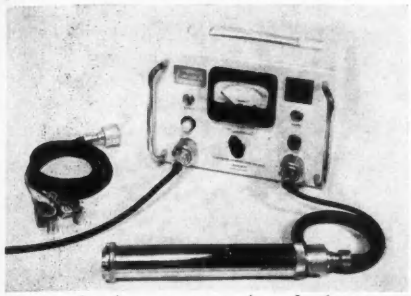
Orders coming in fast? Splendid!
But not if they come in faster than you can handle them. If you can't meet the demand, you may lose that business to your competitors. That's where UDT comes in.
UDT helps you replace old equipment, add new, out of income. Which often means it pays for itself out of increased profits.
A nice business-like way to do business.
If you think UDT could help you, get in touch with the Manager of your nearest UDT office—the address is in your local directory.

United
Dominions Trust
(Commercial)
Limited

United Dominions House
Eastcheap · London · EC3

LOW-ENERGY GAMMA-EMISSION DETECTOR

Designed to detect plutonium at maximum permissible body-burden level, the new mains- or battery-operated model P.N.I. 1080 portable detector announced by The Plessey Co. Ltd., of Ilford, Essex, is essentially a detector of low-energy gamma radiation. However, with slight modification and recalibration, the instrument can also detect the presence of americum, a radioactive substance contained in the plutonium manufactured in the U.K. With another slight modification, it can detect uranium 235, which also emits low-energy gamma rays.

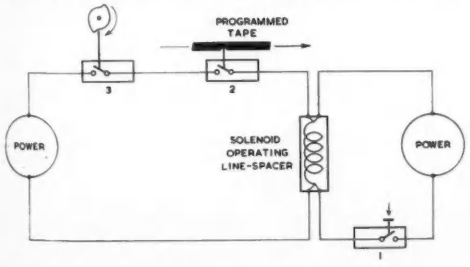


The complete instrument consists of a detector probe and an indicator unit, connected together by 6 ft of cable. The probe comprises a thin, thallium-activated sodium iodite scintillator mounted on the end of a multiplier photo-tube. A chain of resistors is mounted on the inside of the probe, in order to provide the correct potential, and a cable-matching network ensures optimum signal-pulse transfer from the probe to the indicator unit. For use in hospitals, the probe can be enclosed in a polythene container. The indicator unit consists of a pulse amplifier, a preset (though adjustable) single-channel pulse-amplitude analyser, a variable and stabilized E.H.T. supply for the photo-tube, and a display system. All circuits in the indicator unit are transistorized. The sensitivity of the instrument for direct plutonium radiation is 15 cps per microcurie, and about 0·2% of this figure for background radiation.

AUTOMATIC LINE-FINDER FOR ELECTRIC TYPEWRITERS

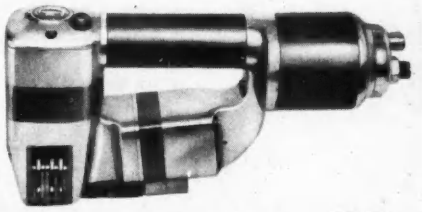
Providing a rapid traverse from one section of a form to another, a new automatic line-finder, produced by W. H. Smith (Alacra) Ltd., of London, N.W.10, enables any chosen part of the typing paper to be brought into position immediately, without repeated use of the line-spacing lever, moving the paper at a rate of six lines per second and stopping at a precisely predetermined point.

As shown in the schematic circuit diagram, the device, which is designed to fit any standard electric typewriter, is programmed by means of a notched tape, which moves in parallel with the paper and which can be changed to cater for the requirements of different business forms. Whenever the typist presses the line-finder microswitch (1), the tape, and the paper with it, traverse the distance between one notch on the tape and the next. Two circuits are used, one to initiate movement of the paper, and the other to maintain this movement until the new typing line is reached. Thus, when the operator presses microswitch (1), the first circuit is closed, energizing a solenoid to move the paper and the tape up by one line. At this point, it would stop, were it not for the second microswitch (2), which is installed against the programming tape in such a way that the thickness of the tape is sufficient to depress the plunger and close the contact, the initial movement of the tape taking the notch away from the switch plunger, and causing an unnotched section of the tape to close the contacts. In the same circuit, in series with microswitch (2), is another microswitch (3), with a minimum life of 10,000,000 operations. This switch makes contact six times per second by means of a cam revolving during the whole period of operation of the typewriter. Power is thus provided for energizing the solenoid repeatedly until the next notch in the tape opens the contacts of microswitch (2). When this occurs, the paper comes to rest in its new position.



PUSH-BUTTON PNEUMATIC HAND STRAPPING TOOL

Operating off a small compressor or standard air line, the new " Straplicator " hand strapping tool announced by the Packers Supply Co. Ltd., of New Malden, Surrey, has not only been designed for efficient strapping, but also with a view to eliminating operator fatigue. Thus, the tool weighs only 7 lb and measures only 11 × 5¼ × 2¾ in., though it can be used with ½-, ⅝-, and ¾-in. width strapping in a wide range of gauges. Moreover, as no part of the tool is ever under the strapping, it can be used in any position on virtually any shape of package.



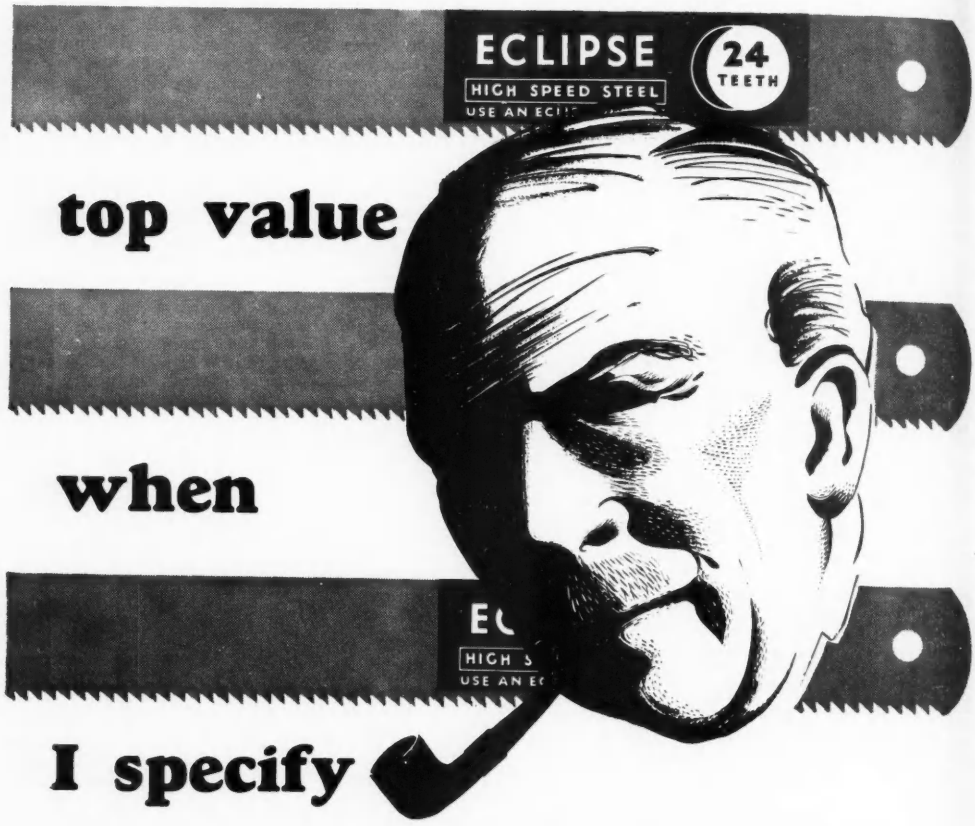
Tension is predetermined by setting a calibrated dial on top of the tool, this tension remaining constant until it is reset. In operation, all that is required is to position the tool and to press a button, after which the strapping is automatically tensioned to its preset value, followed in sequence by a sealing operation and finally the cutting off of the surplus strapping close to the seal. The whole operation, from feed to cut-off, takes between three and four seconds only, and provides an extremely strong and secure sealed joint.

TRANSISTORIZED PORTABLE ELECTRONIC LUNG

With the conventional iron lung, the patient is confined in what is essentially an airtight box, so that he has no liberty whatsoever. Furthermore, as only the head of the patient is outside the lung, his dependence on nursing staff is complete, while serious transport problems arise when it is necessary to move a patient, owing to its size and weight. In short, although the iron lung is undoubtedly an effective machine for maintaining life by providing prolonged artificial respiration in cases of poliomyelitis, it has certain inherent disadvantages, and attempts have been made to produce alternative equipment of a more portable nature.

It is true that portable mechanical lungs or ventilators have been manufactured. It should, however, be noted that the number of respirations per minute, the ratio of inspiratory to expiratory time, and the volume of air entering and leaving the lungs are important parameters,

I buy



top value

when

I specify

Eclipse

HACK SAW BLADES

'Eclipse' hacksaw blades and other tools are made by James Neill & Co. (Sheffield) Ltd. and are obtainable from all tool distributors.

UH36

and that mechanical lungs generally have the disadvantage that variation of one of these basic parameters can cause fluctuations in both of the others. It is now reported, however, that this disadvantage is eliminated in the new portable electronic lung manufactured by W. Watson & Sons Limited, of Barnet, Herts., a member of the Pye Instrument Group, this lung permitting any or all of these parameters to be adjusted immediately and accurately within physiological limits.

In the new machine, which is designated the Barnet ventilator, the patient is linked to the lung by two plastic tubes, and enjoys considerable freedom. Breathing is sustained by the alternation of positive and negative pressure, air being pumped into the lungs during the positive phase and extracted during the negative phase, with precise control of all basic parameters. Weighing only 56 lb, the new lung is extremely portable and incorporates a transistorized circuit and built-in batteries, enabling it to operate for up to 20 hr without the need for recharging. This ability to function for long periods without external power requirements, coupled with its light weight, makes it possible to move patients over considerable distances, even by aircraft, without difficulty.

Quite apart from its use in poliomyelitis, the equipment can be used in practically every case of respiratory insufficiency arising from any cause. For instance, in the event of complete cessation of breathing, it can be used in an attempt to initiate a breathing cycle which, once established, follows the normal rhythm of the patient's breathing by virtue of a special "patient-demand" mechanism incorporated. Similarly, it can also be employed in operating theatres during the administration of anaesthetics.

PORTABLE RADIOACTIVE-CONTAMINATION MONITOR

The new Type-1 portable contamination monitor announced by E.M.I. Electronics Ltd., of Hayes, Middlesex, can be used for monitoring radioactive contamination on benches, clothing, and similar objects. Incorporating all-transistorized circuitry, the instrument weighs about 11 lb, and measures only $11\frac{1}{2} \times 8 \times 8\frac{1}{2}$ in.

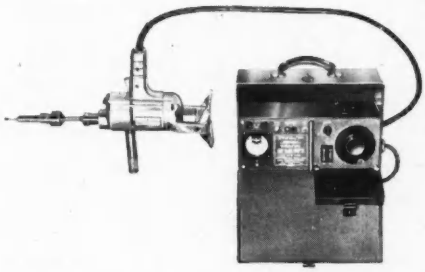
The new monitor utilizes the company's special dual-phosphor technique, enabling both alpha and beta contamination to be monitored simultaneously, separate distinctive tones being provided for both types of radiation, either on headphones or through a built-in loudspeaker. A high-pitched tone indicates alpha contamination, and a low tone beta contamination, both tone being heard when both alpha and beta radiations are being monitored. When the type of contamination has been identified, an accurate check can be made on either the alpha or beta positions.

By operation of a single switch, it is possible to monitor the sum of alpha and beta contamination, or just alpha or beta contamination alone. The information is in the form of counts per second and is displayed on a meter covering a range from 0 to 5000. For monitoring very low alpha activities, an electro-mechanical register is included, giving a more accurate display at rates below about 6 per second.

AUTOMATIC TUBE-EXPANDING UNIT

Based on the principle that the best method of obtaining correct tube-expanding conditions for condensers, heat exchangers, etc. is by determination and limitation of the torque requirements of the expander tool, the new Mk. IV electric automatic torque-control unit announced by Charles Wicksteed and Company Limited, of Kettering, permits the achievement of rapid and consistent expansions. The range handled by the unit is approximately $\frac{3}{8}$ to 1 in. o.d., but other sizes closely outside this range can be accommodated, depending on the material, tube-wall thickness, etc.

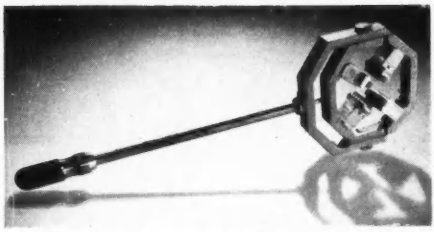
The unit is contained in a compact steel case measuring 14 × 9 × 6 in. and weighing 19 lb. The torque-



setting control has a separate lockable lid to prevent unauthorized alteration. A voltmeter and an indicator knob and dial are provided for easy compensation of voltage variations. The motor is a conventional portable electric-drill type of machine, fitted with an adjustable ball-bearing thrust type of expander. The motor is automatically reversed by means of relays when the expanding operation is completed, but provision is made for stopping and reversing the motor at any time in case of emergency.

LATHE TOOL FOR HONING STRAIGHT OR CRANKED SHAFTS

Suitable for honing and superfinishing straight, cranked, and multi-diameter shafts, the "Lathe Hone", announced by Nicol and Andrew Ltd., of Hillington, Glasgow S.W.2, consists of a split head which carries four abrasive stones in shoes and which is clamped around the workpiece on the lathe. A centre-spindle attached to a hand-screw adjustment passes through a main support rod, permitting fingertip control of the pressure of the abrasive stones on the workpiece. The main support rod travels through a sleeve, which is pivoted on a secondary rod working in a sleeve block located in the lathe toolpost. The hone then automatically follows the "throw" of a cranked shaft rotating in the lathe, but is still under the pressure control of the operator. As the secondary rod is held firmly in the sleeve block, it permits lateral stroking movements on the workpiece to be made.

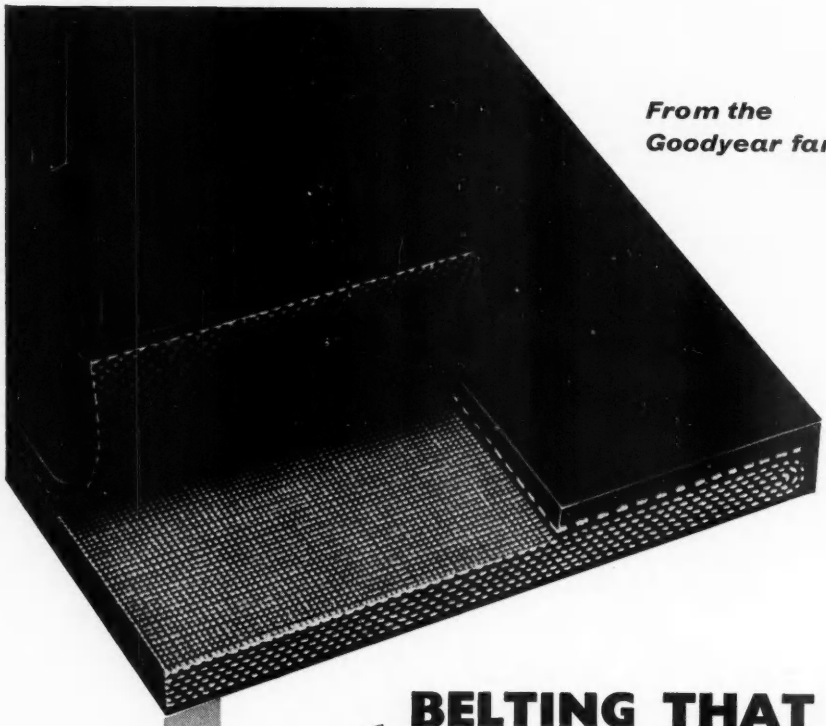


The new lathe tool is available in four sizes, i.e., for diameters of from 2 to 4 in., from 4 to 6 in., from 6 to 9 in., and from 9 to 12 in. respectively, the size of the lathe bed being the only restriction on the length of shafts which can be honed and superfinished.

ELECTRONIC REGISTRATION AND CONTROL UNIT FOR PACKAGING LINES

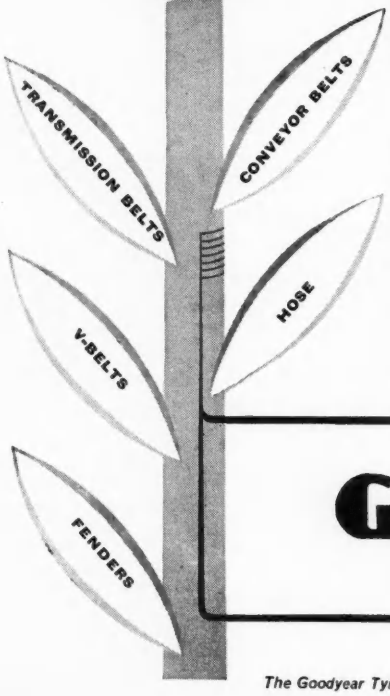
Primarily intended for use in production lines, particularly in connection with packaging, the new type-R.E.1 electronic registration and control unit introduced by the Electronic Machine Co. Ltd., of Thornton Heath, Surrey, makes it possible to line up and control with great accuracy conveyorized items for sorting or further processing.

Basically, the equipment comprises a power-supply and amplifier unit and a scanning head, consisting of



From the Goodyear family tree

BELTING THAT TAKES A LOT OF BEATING



Whatever material you want to move, whatever the conditions, you'll find the conveyor belt for the job in the Goodyear family tree! For abrasive coke or hot sinter . . . oily materials or sharp stone . . . food and coal . . . a 'job-designed' Goodyear belt is your best choice for longest, low-cost performance. Special features include: good troughing, high impact resistance and flex life, and resistance to mildew. Get in touch with Goodyear now for Britain's most comprehensive conveyor belt service.

- Tough cover compounded to suit job
- Breaker fabric between cover and carcass—where required
- Plies of close-woven cotton duck, or synthetic fibres, mildew inhibited
- Skim coat between plies to increase flexibility, prevent separation
- Substantial edge cover to resist wear

GOODYEAR

THE GREATEST NAME IN RUBBER

The Goodyear Tyre & Rubber Company (G.B.) Ltd., Industrial Rubber Products Dept. Wolverhampton

reflector-type photocells and a lamp unit, used in conjunction with a small registration mark on the package or other item to be scanned. This mark usually takes the form of a small rectangle, which can be printed on the material at the same time as the main design. In operation, light is projected through a small opening in the scanning head onto the material to be registered or controlled and is then reflected back into the head and picked up by a pair of photocells. Changes in the density of the light reflected back onto these cells depend on the colour of the material, and these changes in density set up in the cells different voltages. When the registration mark passes through the light beam, the resulting change in voltage is amplified and used to actuate a relay.

As an example, when packaging various types of heat-sealing films, it is essential that the heat-sealing jaws of the machine must operate at the correct moment, necessitating that the package must stop in the right position. This can be accomplished without difficulty and consistent accuracy by means of the new equipment and the use of a registration mark on the package. Similarly, by printing a different registration mark on cartons containing different types of product, but travelling on the same conveyor, they can be sorted and made to stop or divert from the conveyor at predetermined stations.

VIBRATION-SENSITIVE SWITCH FOR PROTECTING EQUIPMENT

The Model 66 "Vibraswitch" announced by the Robertshaw-Fulton Controls Company, of Richmond, Virginia, is a vibration-sensitive device which protects rotating and reciprocating machinery from extensive damage caused by malfunctioning. When the vibration level of the machine exceeds its normal value by a preselected amount, e.g., as a result of failing bearings, broken blades, etc., an internal switch closes, actuating either an audible warning system or a shut-down circuit. The sensitivity of the instrument increases with frequency, making it equally suitable for sensing increases in amplitude at the operating speed or high-frequency chatter, noise, or shock associated with many types of malfunctioning, thus providing complete protection.

The device employs a magnetic circuit opposed by inertial and adjustable spring forces in the actuating mechanism. The armature is constrained to only one type of movement by a frictionless flexure pivot, composed of two overlapping blocks and a leaf-spring loaded in one direction to hold the blocks together. The armature rocks on the pivot and is forced in one direction by the adjusting spring and in the other direction by the magnet. When the entire assembly is subjected to vibration perpendicular to the base, an inertial force, aided by the spring, tends to pull the armature away from a stop-pin and open the air gap. When the peak acceleration exceeds a preselected level, the armature leaves the stop-pin, increasing the gap, the armature continuing to move up until it strikes a latch magnet, actuating the switch during the upward travel.

The switch can be reset by depressing a reset button or applying power to an electrical reset coil. The effect of temperature in the mechanism is negligible, as the elastic modulus of the adjusting spring and the magnetic flux through the air gap both decrease slightly with increasing temperature. The position and method of mounting vary with the type of machine to be protected and with the type of vibration likely to be encountered. However, exact location is not critical, as the setting procedure, which is easily carried out, automatically accounts for normal or existing vibration. If required, time-delay circuits are available in a separate control unit, so as to prevent shut-down except when increased vibration or repetitive shocks persist for several seconds.

The Machining of Reactor Materials

(*Concluded from page 502*)

tionship[13], assuming an average gamma energy of 1 MeV:—

$$S = \frac{6P}{A_f}(d^{-1\cdot2} + 3d^{-1\cdot4}) \times 10^{17} \text{ [photons/sec]}$$

where S is the source strength, P is the percentage of fuel burned up, A_f is the atomic number of the fuel, and d is the time [days] after the fission products are produced. From this relationship it can be shown that the intensity of radiation at 1 metre distance from 1 gram of fuel material which has had 1% of its fuel atoms burned up in a 30-day period and has cooled for an additional 10 days, is of the order of 100,000 times the allowable dose rate. This should clearly indicate that the handling of spent fuel elements will require elaborate facilities for the remote handling of fuel slugs, and careful control to prevent the release of radioactive material from the fabrication facility. These systems will require extensive shields to reduce the external radiation to tolerable levels.

There is only a negligible effect on the physical properties of tools, machines, and associated equipment exposed through manufacturing usage to neutrons resulting from the decay of radioactive fission products. Maintenance of equipment will be greatly complicated by the high levels of radioactive contamination. Automatic systems of machine tools have found a definite application in this area[14].

Finally, it may be said that developments of new materials for high-temperature service in aircraft, missile, and nuclear-reactor applications can be expected and will involve new processing and machining problems.

REFERENCES

(1) L. J. BARRON: "Titanium and Zirconium in Chemical-Plant Applications"; *Mallory-Sharon Special Metals Digest*, Issue No. 2, winter, 1959.

(2) "Technical and Application Data on Zirconium and Hafnium"; Mallory-Sharon Metals Corporation, Niles, Ohio.

(3) A. O. SCHMIDT and J. R. ROUBIK: "Machining of Zircaloy"; *The Tool Engineer*, Vol. 43, No. 5, November 1959.

(4) B. LUSTMAN: "Fuel for the Atomic Engine"; *Metal Progress*, Vol. 75, No. 4, April 1959.

(5) B. MANSON: "An Economic Appraisal of Stainless Steel and Zirconium in Nuclear Power Reactors"; *Metal Progress*, Vol. 75, No. 2, February 1959.

(6) S. J. PAPROCKI, E. S. HODGE, and C. B. BOYER: "Preparation of Reactor Components by a Gas Pressure Bonding Technique"; *Mechanical Engineering*, Vol. 81, No. 1, May 1959.

(7) A. O. SCHMIDT and J. R. ROUBIK: "Some Thermal Aspects of Metal Cutting"; *The Tool Engineer*, Vol. 21, No. 5, November 1948.

(8) A. O. SCHMIDT: "Analysis of Maximum Temperatures in Workpieces"; *The Tool Engineer*, Vol. 31, No. 1, July 1953.

(9) A. DENST and H. V. ROSS: "How to Machine Uranium"; *American Machinist*, Vol. 99, August 1, 1955.

(10) B. J. RAMBOLL and K. V. OLSEN: "Cementing Houses of Lightweight Concrete"; *Ingenioren* (Denmark), No. 46, November 12, 1955.

(11) W. A. BROST: "Health and Safety Considerations for Uranium Fuel Fabrication Facilities"; U.S. Atomic Energy Commission, Bulletin No. COO–212.

(12) C. F. BONILLA: "Nuclear Engineering"; McGraw Hill, 1957.

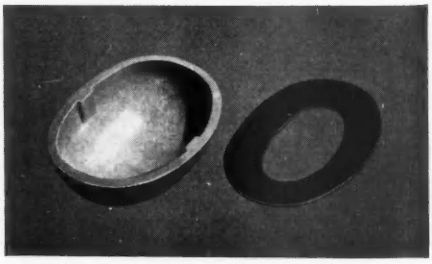
(13) K. WAY and E. P. WIGNER: *Physics Review*, Vol. 73, 1948, p. 1318.

(14) S. E. DISMUKE: *American Machinist*, April 12, 1954, pp. 161–165.

Here's a typical example of how the mechanical strength of Beetle D.M.C. (Dough Moulding Compound) helps to solve industrial problems.

These ear defenders are used to protect the hearing of workers in proximity to jet engines and in noisy factories. During the development work by the makers, Dennis Ferranti Meters Ltd., twelve sets moulded from conventional materials were delivered to Bomber Command for testing. The report of The Central Medical Establishment, Acoustics Laboratory, was that the ear defenders gave excellent protection, but that the mouldings then used were considered too fragile. D.M.C. mouldings were substituted and have been found virtually indestructible.

D.M.C. is the ideal material whenever high mechanical and/or electrical strength is required. The material can be moulded in conventional compression presses on short cure times and at low pressure. We shall be glad to send full technical details.



This illustration shows the main moulding from Beetle D.M.C. and a retaining piece made from Scarab material. The Earguards are used in engine testing, rivetting, blasting, rolling mills, weaving sheds, paper mills and on aerodromes.

B·I·P

BEETLE MOULDING POWDERS

B.I.P. CHEMICALS LTD., Oldbury, Birmingham. Telephone: Broadwell 2061

London Office: 28 Haymarket, S.W.1. Telephone: TRAfalgar 3121/8.

NEWS OF THE MONTH

PERSONAL

Mr. John Harrison has been appointed managing director of Atlas Copco (Great Britain) Ltd., in succession to **Mr. J. C. Greig,** who has resigned.

Dr. Robert Hunter, deputy managing director of The Clyde Alloy Steel Co. Ltd., has been elected chairman of the Council of the British Castings Research Association. **Mr. W. S. Scott,** a director of Darlington Forge Ltd., has succeeded Dr. Hunter as vice-chairman of the Council.

It is announced by Volex Electrical Products Ltd., of Salford, that **Mr. R. Tearse, A.M.I.E.E.,** has joined the company in charge of a newly formed Technical Department for the development and sales of special cables, primarily for space-heating.

Acheson Industries (Europe) Ltd. announce the election of **Mr. Edward A. Smith,** executive manager, to the board of directors of Acheson Colloids Limited.

Sir Philip Southwell, C.B.E., M.C., who recently retired as managing director of the Kuwait Oil Company, has now been appointed chairman of the British subsidiary of Brown & Root, Inc., of Houston, Texas, with London offices at 6 Arlington Street, St. James's, London, S.W.1.

Mr. E. R. Lewis, chairman of the Decca Group of companies, and **Group-Captain E. Fennessy, C.B.E.,** managing director of Decca Radar Limited, have joined the board of General Precision Systems, following the acquisition by Decca Radar Limited of a 25% interest in that company. The two companies have agreed to co-operate in the development of air-traffic control systems.

Mr. P. Beynon has been appointed works manager, operational research and work study, at Steel, Peech and Tozer, a branch of The United Steel Companies Limited.

Mr. W. A. Galbraith, B.A.(Eng.), M.A.(Cantab.), A.M.I.Mech.E., has been appointed general sales manager of The Yale & Towne Manufacturing Company's British Materials-Handling Division at Wednesfield, Staffs. **Mr. H. Davis** has been appointed sales manager (U.K.), and **Mr. M. J. Stewart,** sales manager (export).

Mr. J. E. Smith will become managing director of the National Gas & Oil Engine Company Limited on January 1, 1960, and will also become a member of the board of Hawker Siddeley Industries Limited.

Mr. K. R. Simmonds, B.Sc.(Eng.), A.M.I.E.E., has been appointed general manager of the International Rectifier Co. (Gt. Britain) Ltd., of Oxted, Surrey.

It is announced by George Ellison Limited, of Perry Barr, Birmingham, that **Mr. T. G. Ellison** and **Mr. A. E. Skan** have been appointed joint managing directors of the company.

Mr. C. J. Beavis has been appointed by Birlec-Efco (Melting) Limited to take charge of all the company's smelting activities.

It is announced that **Admiral Sir Michael M. Denny, G.C.B., C.B.E., D.S.O.,** has been appointed a director of the English Steel Corporation, Ltd.

The Plessey Company Limited announce the appointment of **Mr. R. E. Verguson, M.S.M.A.,** as commercial manager of a new grouping, which includes the Sheet-Metal Division and the Amar Tool and Gauge Company Limited with the Industrial Hydraulics Division, at Cheney Manor, Swindon.

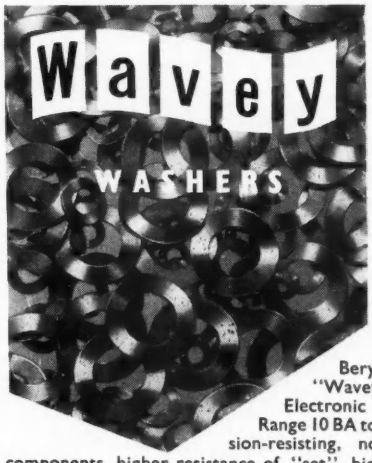
Consequent on the recent death of **Mr. R. B. Dakin,** who was deputy chairman and joint managing director of Walter Somers Ltd., of Hales Owen, **Mr. W. Somers** has been appointed deputy chairman and joint managing director, while **Mr. A. C. Somers** has been appointed sales director. **Colonel T. V. Somers, O.B.E.,** has been appointed production director, and **Mr. D. C. Tyson,** assistant production director. **Mr. W. M. Grainger,** secretary, and **Mr. D. D. Carrington,** engineer, have both been appointed to the board of directors.

Mr. A. B. Clarke, A.S.M.A., M.S.I.T., formerly instrumentation sales manager of J. Langham Thompson Limited, has been appointed sales manager of Cossor Instruments Limited.

Following the recent death of **Mr. L. K. Everitt** and the retirement of **Mr. H. D. Boyd,** Edgar Allen & Co. Limited, of Sheffield, have appointed **Mr. F. A. Ross, Mr. W. G. A. Jenkins,** and **Mr. J. Higginbotham** directors of the company.

It is announced by Opperman Gears Limited, of Newbury, Berks., that **Mr. A. Barton** has been appointed works manager of the company.

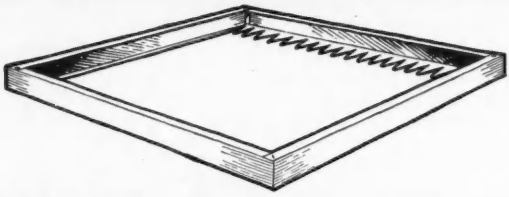
It is announced by the English Steel Corporation Ltd. that **Mr. W. D. Pugh** has been appointed chairman of the English Steel Forge and Engineering Corporation Ltd., the English Steel Rolling Mills Corporation Ltd., the English Steel Castings Corporation Ltd., the English



Beryllium Copper "Wavey" Washers. For Electronic Components. Range 10 BA to ⅝" BSF. Corrosion-resisting, non-damaging to components, higher resistance of "set", higher recovery of load, permanent spring action. They are fabricated from Beryllium copper, heat treated to VPN. 350 minimum, Electro Plated to DTD.924, Cadmium plated to DTD.904 and Passivated to DTD.923. Also supplied Silver Plated, or Self Colour or to customer's specification. Samples and price lists on request.

THE LEWIS SPRING CO. LTD
RESILIENT WORKS, REDDITCH
TEL. REDDITCH 3771/PBX
London Office: 122 High Holborn, W.C.1. · Tel: Holborn 7470 & 7479

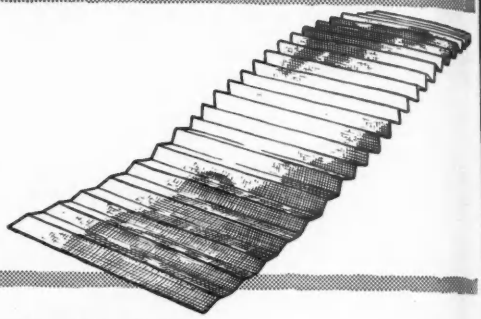
LEAVE IT TO **Lewis** OF REDDITCH
SPRINGS, SPRING CLIPS
PRESSWORK, WIRE FORMS
VOLUTE SPRINGS

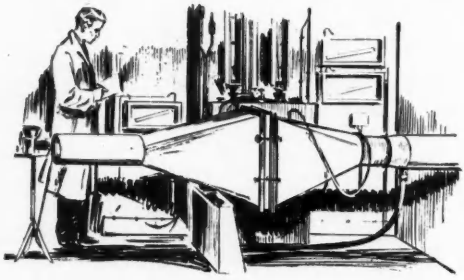


A low-cost expendable frame

fitted with a large area of unique filtering medium,

The synthetic fibrous medium is impregnated with a newly developed adhesive which adds to its efficiency and effective life. Unaffected by moisture, non-cracking, and free from fibre migration, the medium is supplied in flame-resistant form. It is pleated to present the greatest possible filter surface in the most compact space.





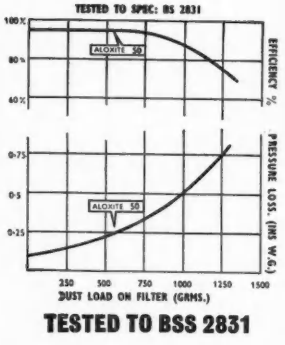
backed by all the resources of Vokes laboratories,

Vokes is an entirely British company and therefore tests its filters to British standards. All Vokes air filters are tested to BSS 2831 in their well-equipped laboratories, where research into new filter materials is continuously carried on.

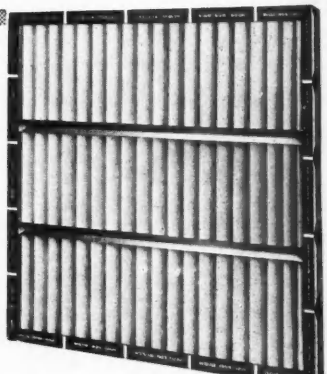
make up Vokes new *Super-Vee** Air Filter

Vokes Super-Vee Air Filter with its sustained efficiency under severe industrial pollution and smog conditions is the best low-cost, long life expendable air filter for paint finishing plant, chemical laboratories, textile plant, distilleries, nuclear power plant and most heating and ventilating applications. IT IS FULLY INTERCHANGEABLE WITH OTHER SIMILAR PANELS. Comprehensive testing to BSS 2831 showed that the dust-holding capacity for a given rise in pressure loss, with no drop in efficiency, exceeds that of any other filter panel of this class.

* *Registered Trade Name*
WORLD WIDE PATENTS PENDING



TESTED TO BSS 2831



Size for size with similar filters the Super-Vee offers up to 25% greater capacity thereby considerably reducing the number of panels needed for any particular application, allowing a more compact installation *and* lower maintenance costs.

VOKES

VOKES LIMITED • HENLEY PARK • GUILDFORD • SURREY

Telephones: Guildford 62861 (6 lines)
Telegrams: Vokesacess, Guildford, Telex.

Telex 13-535 Vokesacess, Gfd.
Represented throughout the world.
V503

Steel Spring Corporation Ltd., and Taylor Bros. & Co. Ltd. **Mr. W. E. A. Redfearn** becomes managing director of the English Steel Forge and Engineering Corporation Ltd., while **Mr. R. G. H. Taylor** and **Mr. G. Craven**, have been appointed respectively chairman and managing director of the English Steel Export Corporation Ltd.

Consequent on the retirement of **Mr. J. M. E. Fell**, A. E. C. (Sales) Ltd. announce that **Mr. J. Cooke** has been appointed director-export.

Mr. J. A. Hepworth, B.Sc., M.Inst.Gas E., has been appointed chief engineer of the North Thames Gas Board, in succession to **Dr. J. Burns,** who becomes deputy chairman of the board.

BUSINESS NOTES

It is announced by **Aerox Limited,** manufacturers of aeration, filtration, and fluidizing equipment, that they have outgrown their premises at Crawley and have now acquired a much larger factory for their engineering section, with five times the floor space and improved facilities, at Chalford, Stroud, Gloucestershire.

Burton, Griffiths & Co. Ltd., of Kitts Green, Birmingham, and **Delapena & Son Ltd.,** of Cheltenham, announce that they have joined forces for the distribution of Delapena honing machines and equipment in the U.K. (including Northern Ireland).

Agreement has now been reached between the **Lester Engineering Co.,** U.S.A., and **Brockhouse,** of London, for the latter company to construct, under licence, their 4/6 and 6/9 oz injection-moulding machines for sale in the U.K. and throughout the Commonwealth. Production of these machines is due to start very shortly.

Nash & Thompson Ltd., of Surrey, announce that they are now the exclusive selling agents in the U.K. and Commonwealth for KOVO, the foreign trade organization for the import and export of precision engineering products made in Czechoslovakia, including polaroscopes and polarographs designed at Professor Heyrovsky's Polarographic Research Institute in Prague.

Specially established to advise on complete automation schemes and the supply of Gresham unit sequencing systems, together with all other ancillary instruments and controls, a separate company, **Gresham Automation Ltd.,** has been formed. The address of the company is Gresham House, Twickenham Road, Hanworth, Middlesex, and the directors are Mr. J. P. Coleman, M.I.E.E., chairman of **Gresham Transformers Ltd.** and of the **Gresham Lion Group,** and Mr. R. M. Campbell, who is also a director of Gresham Transformers Ltd. Dr. D.B. Foster, Ph, D., M.I.Mech.E., M.I.E.E., M.I.Chem.E., F.Inst.Fuel, is consultant to the board.

As a result of an agreement between **S. Smith & Sons (England) Ltd.** and the **Torrington Manufacturing Company,** of Torrington, Conn., U.S.A., a newly-formed department of the Smith organization will manufacture Torrington air impellers and will market them throughout the world, with the exception of the Americas.

Baker Perkins Ltd., of Peterborough, announce that negotiations are in an advanced stage for the acquisition of the major part of the business of **William Douglas & Sons Ltd.,** of London, i.e., their refrigeration, bulk-handling, and general engineering business. A preliminary agreement has been signed, providing for the formation of a new subsidiary company, **William Douglas & Sons (Engineering) Ltd.**

The **Timken Roller Bearing Company,** of Canton, Ohio, U.S.A., and the **Fafnir Bearing Company,** of New Britain, Conn., U.S.A., announce that they are concluding an agreement in which the **Fafnir Bearing Co. Ltd. (U.K.)** will purchase all the assets and business of one of Timken's British subsidiaries, **Fischer Bearings Company Limited,** of Wolverhampton.

The formation of a joint manufacturing company, to be called the **Lang Gisholt Machine Company Limited,** is announced by **John Lang & Sons Limited,** of Johnstone, Renfrewshire, Scotland, and the **Gisholt Machine Company,** of Madison, Wis., U.S.A. The new company will occupy the existing factory of John Lang & Sons Limited, the manufacturing capacity of which will progressively be expanded.

Crawford Collets Limited announce that **Alfred Herbert Ltd.,** of Carliol Square, Newcastle 1 (Tel: Newcastle 28864) have been appointed their accredited agents for North-East England.

CONTRACTS

It is announced by D. Napier & Son Limited that, despite severe competition from American firms, an agreement has been signed with Napier Engines Incorporated, the company's wholly-owned subsidiary in the U.S.A., covering the purchase of a fleet of Convair-540 aircraft equipped with Napier "Eland" 3500-ehp propeller-turbine engines. The agreement covers purchase terms, maintenance guarantees, etc., and the initial order will be for five of the new aircraft plus spares, with options for ten more.

The largest single installation of induction-heating equipment to be ordered in Great Britain has been secured by the Induction-Heating Division of Garringtons Limited. This order has been obtained in association with Fielding & Platt Limited, who are providing the hydraulic press equipment involved. The plant is for the Ministry of Supply Royal Ordnance factories and has an installed capacity of 3000 kW.

A dollar order valued at about £190,000 has been obtained by the Heavy Plant Division, Rugby, of Associated Electrical Industries for a large turbine-driven centrifugal blower required for a catalytic cracking plant in the new Duque de Caxias oil refinery at Rio de

The Nitriding Process for Case-hardening Special Steels by Nitrogen offers

- Surface hardness up to 1100 D.P.H.
- Retention of full hardness after heating to 500° C.
- Maximum resistance to frictional wear and fatigue.
- Improved resistance to corrosion by water and steam.

Particulars from:—

NITRALLOY LIMITED

ATLAS WORKS SHEFFIELD 4.

Telephone: 26646 Sheffield. Telephone: Nitralloy, Sheffield.

PRODUCTION TOOLING REVOLUTIONISED NEW TOOLING AIDS SERVICE

GIVES OFF-THE-SHELF DELIVERY

Here's great news for British Industry

For the first time in this country a really complete range of standardised precision tooling aids is available for immediate off-the-shelf delivery. This service, developed by the Woodside Die Sinking Company, completely revolutionises production tooling. Now it is possible to choose *all* the tooling aids needed for a specific production requirement from a standard catalogue. Uneconomic "one-off" tooling aids are a thing of the past; so too are production delays and broken delivery dates—the Woodside service with off-the-shelf delivery has ended all that. The Woodside Tooling Aids Catalogue detailing the complete range is available on request, and a staff of experienced engineers is ready to help users plan their production tooling from the outset.

WDS

TRADE MARK

WDS TOOLING AIDS FOR INDUSTRY

Woodside Die Sinking Company Limited, Aire Vale Works, Newlay, Leeds 13

Telephone No. Forsforth 4251/4 Telegrams: Wooddie Leeds Telex No. 55185

A IKC Company

Janeiro. This refinery, which, with an output of 90,000 barrels of oil per day, will be the largest in Brazil, is being engineered and constructed by the Foster Wheeler Corporation, of New York, for Petroleo Brasileiro S.A. (Petrobras). The order for this machine forms part of a contract between Petrobras and Brefcon Ltd. (a consortium of British manufacturers of petroleum equipment) for the supply of plant manufactured in the U.K.

An order worth nearly £250,000 for the 3270-shp diesel-electric propulsion machinery and associated equipment in the new 4000-ton Cable & Wireless cable-repair ship has been received by the English Electric Company Ltd. from the shipbuilders, Cammell Laird. Besides the main and auxiliary diesel-generating equipment, the contract includes propulsion motors, switchgear, control gear, and motors driving the auxiliary machinery. The engineering is being carried out by the company's Marine Projects Division. The four main diesel engines will be made at the company's Rugby works, the auxiliary engines at The Vulcan Foundry, and the heavy electrical machinery and control gear at Stafford.

The English Electric Valve Co., Ltd., of Chelmsford, announce that the Collins Radio Company has placed a $100,000 order for their klystron type K350, which will be used in American-built Doppler navigation equipment. Shipments of tubes to the Collins specifications will commence immediately. The K350 is a forced-air-cooled two-resonator klystron oscillator with mechanical tuning, covering the frequency range from 8500 to 10,000 Mcs, and with an available output power of approximately 1 W. It has been specifically designed with low noise modulation and good frequency stability to meet the exacting demands of the latest airborne FM radar applications. No pressurizing at high altitudes is necessary.

English Electric has been asked by the Central Electricity Generating Board to start work on the two largest single-shaft steam turbo-alternators yet to be built in Europe. The order, one of the most important of recent years, will be worth nearly £5,000,000 and will include the two 350-MW steam turbo-alternators, together with their feed-heating and evaporating plants, for the Drakelow " C " power station in Derbyshire.

ENGINEERING PROBLEMS ANTICIPATED IN SPACE TRAVEL

As announced by The Institution of Plant Engineers, arrangements have been made for Mr. M. J. Brennan, B.Sc., M.I.Mech.E., F.R.Ae.S., to give a lecture on " The Engineering Problems Anticipated in Space Travel " to members and non-members of the Institution on January 18, 1960, at 7.00 p.m. at the Meeting Hall of The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1. Mr. Brennan is assistant chief engineer of Vickers Armstrong Ltd. and was for many years chief designer for Saunders Roe Aircraft Ltd., where he was responsible for the " Black Knight " and other important projects. He is also a member of the Council of the British Interplanetary Society.

Admission by ticket is essential. Tickets can be obtained from The Secretary, The Institution of Plant Engineers, 2 Grosvenor Gardens, London, S.W.1.

FIRST ALL-BRITISH UNBREAKABLE MAINSPRINGS

Samuel Fox and Company, Limited have developed a new stainless alloy specifically for the manufacture of watch and instrument springs. Known as " Fortinox ", the new alloy is already being used in the large-scale production of stainless unbreakable mainsprings for watches and precision instruments at the company's Stocksbridge works, near Sheffield. It is stated that these mainsprings will last the lifetime of any mechanism for which they are designed, and will not show any loss of power during service. Until now, unbreakable stainless spring alloys have not been made in the U.K. and have had to be imported.

DEMONSTRATION OF TAYLOR-HOBSON MEASURING INSTRUMENTS AND MACHINE TOOLS

In 1893, with the advent of the " Cooke " lens, the firm of Taylor, Taylor & Hobson was launched upon its steadily expanding career. However, with the increasing numbers of special-purpose lenses produced, it became necessary to engrave their mounts, and the company decided to design their own machine for this purpose. The result was the world's first pantograph engraving machine.

At a recent demonstration in London of Taylor-Hobson equipment, a range of their latest engraving machines, router-copiers, and cutter grinders was featured, together with representative examples of measuring equipment produced by the company, including their " Talysurf " standards-room instruments for the precision production of ball and roller races, shafts, bearings, slideways, cams, and gear teeth, and their " Talyrond " equipment for the accurate measurement of errors in roundness. Other exhibits included their micro-alignment telescope for precision alignment and checking parallelism, squareness, and plane and horizontal surfaces, their " Talymin " high-magnification gauges for precision gauging and inspection, and a host of other measuring equipment, ranging from continuous gauges for the accurate and continuous reading of strip thickness in rolling mills to a variety of special-purpose microscopes for general workshop applications, for critical viewing of the leading and trailing edges of turbine blades, and for checking the shape and dimensions of cutters.

Frankly, nearly all this equipment is well known and is used throughout the world. There is very little, therefore, that we can say which will serve to enhance its already

PHILLIPS
RECESS
METAL THREAD SCREWS
ANOTHER H. & S. AID TO INDUSTRY!
Speed up production with Phillips Recess Metal Thread Screws and Slotted Indented Hexagon head Machine Screws.
'THE SCREW WITH THE ALTERNATIVE DRIVE.'
INDENTED
HEXAGON HEADS
THOS. HADDON & STOKES LTD.
DERITEND BIRMINGHAM 12

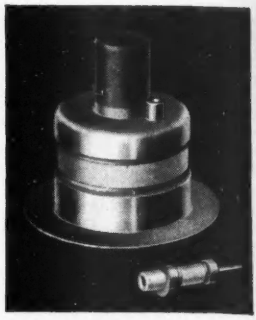
INSULATION AND HIGH TEMPERATURES

material answer to design problems

Sintox Technical Advisory Service.

This service is freely available without obligation to those requiring technical advice on the application of Sintox Industrial Ceramics. Please write for booklet or any information required enclosing blue print if available.

Sintox—an alumina ceramic of exceptional insulation characteristics—stands elevated temperatures with little change in its properties. It is widely used in the Electrical and Electronics industries, and is of great value when small components are needed. Sintox also has great mechanical strength, high thermal conductivity, resistance to corrosion and—for nuclear applications—low neutron capture cross section.



BRAZED METAL/CERAMIC TERMINAL SEALS
These seals are brazed vacuum-tight assemblies capable of withstanding elevated temperatures and pressures under conditions of continuous operation.

SINTOX

precision engineering ceramics

SINTOX IS MANUFACTURED BY **LODGE PLUGS, LTD., RUGBY.**

S.I.

"BROADY"

REDUCING VALVES

For Steam, Air, Water, Gas and Oil.

***Manufactured in:* GUNMETAL CAST IRON CAST STEEL**

A wide selection of valves for pressures up to 6000 lbs/sq. in.

. . . Although there is no better reducing valve than a BROADY—every reducing valve should have a Relief Valve—and we manufacture Relief Valves which are in every way, comparable to our Reducing Valves —so please ask us to quote for both.

As supplied to the largest industrial and shipbuilding Companies in this country and also to the Admiralty and Government Departments.

"Your Problem is our Challenge"

**WILLIAM BROADY & SON LTD.*

ENGLISH STREET · HULL

Grams: Broady, Hull. Telephone: Hull Central 29894 (5 Lines)

**Also for dealing with Superheat conditions.*

well-merited reputation for quality and versatility. We propose, instead, to say a few words about one small range of equipment, certainly not featured and probably overlooked by most of those present at the demonstration. We are referring to a series of the company's industrial lenses with focal lengths of from about ½ to 6 in., which were used in conjunction with a closed-circuit television system. We took the opportunity of testing these lenses at their full aperture of f:1·5 and found their resolution and quality to be quite outstanding. Perhaps, then, it is as well to remember that, although familiarity with this company's lenses can never breed contempt and their excellence is automatically taken for granted, it is not surprising that over 80% of the lenses used in film studios throughout the world, including those in Germany, France, and Italy, are made by Taylor, Taylor & Hobson.

PRIZE OFFER FOR THE FIRST SUCCESSFUL MAN-POWERED AIRCRAFT FLIGHT

It is announced by the Royal Aeronautical Society that a prize of £5000 has been offered personally by Mr. Henry Kremer, chairman and managing director of Microcell Limited, and also a director of B.T.R. Industries and other companies, for the first successful flight of a man-powered aircraft designed, built, and flown within the British Commonwealth under conditions laid down by the Royal Aeronautical Society. These conditions will be announced as soon as possible, and the Royal Aero Club will be invited to act as official observers.

FIRST COMPLETE BRITISH ACOUSTIC LABORATORY

The Acoustical Investigation and Research Organization, Ltd. (AIRO) is the first independent, non-trading organization to be formed in Great Britain for the purpose of practical investigation and research into all aspects of noise problems. It maintains close liaison with the National Physical Laboratory at Teddington and with the Building Research Station at Garston, Watford. As a result, the new AIRO Research Station at Hemel Hempstead has been designed to comply with the recommendations of these two authorities.

The new laboratory is the first in the U.K. to bring under one roof all the special equipment and techniques necessary for acoustic analysis and measurements of every kind. The laboratory undertakes three principal types of work., i.e., (1) measurement of the acoustic characteristics of machines, materials, and electro-acoustic transducers, (2) development projects involving acoustical problems, and (3) fundamental research in the field of acoustic engineering and electro-acoustics.

Two of the experimental test-rooms require maximum insulation from extraneous noise, these being the anechoic chamber, which must be echo-free, and the reverberation chamber, where all surfaces reflect noise. To achieve the necessary degree of insulation, both these chambers are separately supported on high-compression rubber mountings. They are therefore completely independent of the structure of the building. In addition, incoming ducts and leads are insulated, and a mineral-wool blanket is suspended in the cavity between these chambers and the main structure.

In the anechoic chamber is a sound-absorbent lining on all walls, floor, and ceiling, in a specially devised formation, up to a thickness of 30 in. A retractable metal-grid floor is used for setting up experiments. In the reverberation chamber, all surfaces are reflective, and adequate diffusion of sound is obtained by introducing reflector plates suspended from the ceiling. This technique has not been used previously in this country and is now internationally accepted.

In the ceiling of the reverberation chamber is a precast concrete panel which can be raised by hoist into the upper source chamber above. It can then be removed along a gantry and lowered to ground level for resurfacing with new materials which require to be tested for sound-transmission properties. No two walls in the reverberation chamber are parallel to one another, the object being to prevent undesirable effects associated with rectangular rooms. The same requirement applies to the source chamber, which, although not suspended independently, has highly-reflective surfaces and no two walls in parallel. All experimental chambers are between 14 and 17 ft. in height.

Classified Advertisements

The rate for all classified advertisements is 9d. per word : in bold print 1s. per word : minimum order 10s. Box-number advertisements 1s. extra. Semi-displayed advertisements on this page 60s. per single column inch. Instructions, together with remittance, must be received not later than the 1st of each month for advertisements to appear in the same month's issue.

SITUATIONS VACANT

THE PERMUTIT COMPANY LTD.

invite applications from a

SENIOR MECHANICAL DESIGN DRAUGHTSMAN, with experience in design of hydraulic control equipment
and a
SENIOR ELECTRICAL DRAUGHTSMAN with experience in design of automatic control circuits and instrumentation.
These are permanent and pensionable positions with a good starting salary. Please apply to:
The Personnel Officer, Permutit House, Gunnersbury Avenue, W.4.

WANTED

Wanted. Representatives for correspondence abroad, high earnings, written instructions. Write: Fortuna Publishing Co., Vienna 1/8, Postfach 49.

FOR SALE

12 ft. × ½ in. BENNIE FOLDING MACHINE for sale. Motor driven Swing Beam Universal Folding, Rounding and Box Forming Type. Max. lift of top beam 18½ in. Adjustment to bed and folding beam 8 in. Smallest trunk formed over bed 18 in. × 18 in. Largest tube formed 16 in. diameter. Gearbox drive with lever control to reversing friction clutches, operating all beams. Safety slipping clutch between gearbox and main drive shaft. Weight about 14 tons. Full details, illustrations, etc., from F. J. Edwards Limited, 359 Euston Road, London, Euston 4681 or 41 Water Street, Birmingham 3, Central 7606.

OSMOND

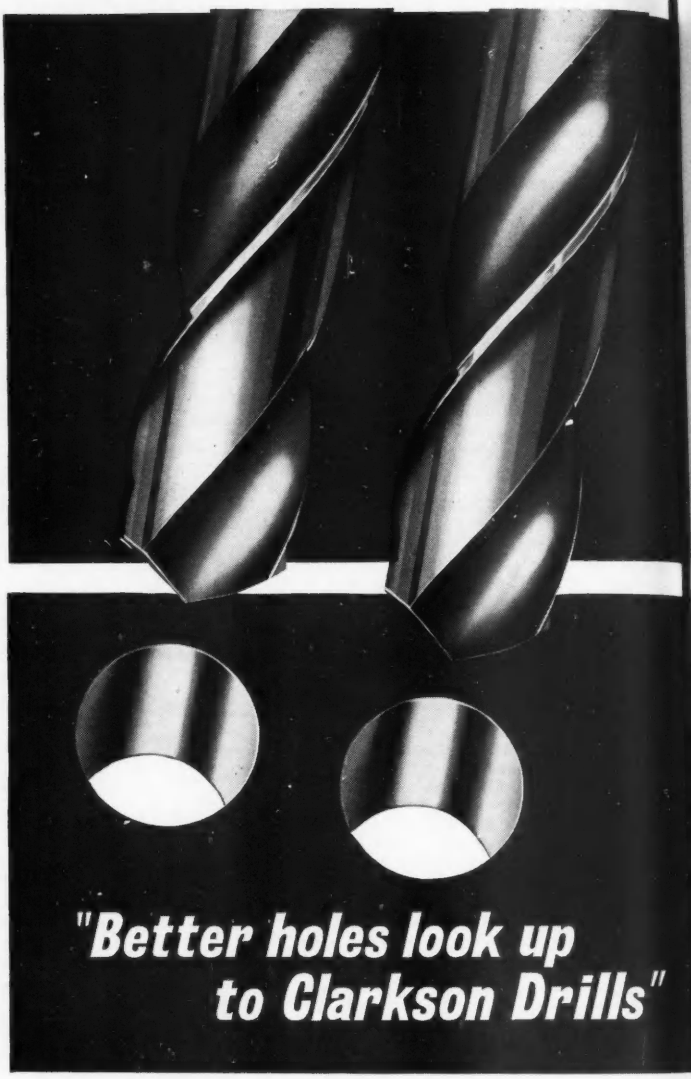
CUTTING OFF MACHINES

A. & S. OSMOND, LTD.
13 DOWRY SQ., BRISTOL.

Telephone:
Bristol 27604

Anderton CIRCLIPS

CATALOGUE from ANDERTON SPRINGS Ltd. (A2) BINGLEY 2388
London Office: HOLborn 5151



Holes made by Clarkson Drills are the type that bring an appreciative nod from the most fastidious inspector. For there's no doubt about it, Clarkson Drills are already achieving the high reputation set by Clarkson Chucks and Cutters. No ordinary drills these. They have the extra inbuilt quality that makes better, cleaner, more accurate holes at greater speed. They are better drills, made to give longer life between regrinds.

Buy Clarkson with confidence—you cannot use a better drill. Sold only through Clarkson branches to ensure instant delivery.

Clarkson Drills

THROUGH & THROUGH — THEY'RE CLARKSON

CLARKSON (ENGINEERS) LTD., NUNEATON. Tel : 2261

Please send for literature giving details of Clarkson Drills and prices.

Name.....

Address.....

B .....

Branches at

BELFAST Tel.: 20025. LEEDS Tel.: 26369. NEWCASTLE Tel.: 2-5248. LONDON RIVerside 8241. BIRMINGHAM VICtoria 3994. BRISTOL Tel.: 2-8464. CLASGOW SOUth 1942. MANCHESTER ARDwick 4804.

NEW TECHNICAL BOOKS

Explosions, Detonations, Flammability, and Ignition. By S. S. Penner and B. P. Mullins. 298 pp., 105 illustrations. Publishers: Pergamon Press Ltd., 4 & 5 Fitzroy Square, London, W.1. Price: 70/–.

Written with reference to first principles and suitable not only for advanced college students, but also for active research scientists and engineers in all branches of combustion, this excellent book reviews the current state of knowledge of explosions and their prevention, and of detonation, inflammability, and ignition.

An unusual feature of this book is that the same material is discussed by two different authors from entirely different viewpoints, the one analytical and the other semi-empirical and practical. Thus, Part I, by Penner, who is Professor of Jet Propulsion at the California Institute of Technology, is concerned with selected analytical studies of explosions, detonations, inflammability limits, ignition of gases, and heterogeneous burning, with some emphasis given to the powerful technique in theoretical combustion research introduced by Schvab and Zeldovich. On the other hand, Part II, by Mullins, who is Senior Principal Scientific Officer at the National Gas Turbine Establishment, Farnborough, Hants., deals with experimental and theoretical studies of inflammability, ignitability, and explosion prevention, and includes a thermal hypothesis, which might be described as a generalization of Semenov's conception of ignition temperature, and which is shown to be of great use in predicting combustion phenomena, such as inflammability limits and flash-points and the effects of diluents on limiting combustion processes.

The Design and Construction of High-Pressure Chemical Plant. 2nd Edition, 1959. By Harold Tongue, C.B.E., M.I.Mech.E., A.M.I.Chem.E. 262 pp., 281 illustrations. Publishers: Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price: 84/–.

As Sir John Cockcroft points out in his foreword to this excellent book, ". . . much development has occurred since its first edition in 1934, not only in the greatly increased use of high pressure in the chemical industry, particularly in petrochemicals, but also in the applications of high-pressure technology in the design of reactors and auxiliary equipment for nuclear power plants, some of which are really chemical-engineering projects. . . ."

As a result, this new edition has been extensively revised, and includes descriptions of many new developments. Nevertheless, it preserves the original aim of the first edition to provide a practical guide and reference work, with actual examples and dimensioned drawings, of the whole range of high-pressure equipment used in the chemical industry. Reference is also made throughout the book to the high-pressure techniques developed in the design of nuclear power reactors.

Microwave Data Tables. By A. E. Booth, M.I.R.E., Graduate I.E.E. 61 pages. Publishers: Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.I. Price: 27/6.

Primarily intended for engineers and others engaged in research and development work involving waveguides and similar transmission lines, this book comprises a collection of accurately computed tables, which will effect an appreciable reduction in the time that must otherwise be spent on tedious calculations.

This useful book, clearly printed and strongly bound to withstand constant usage, contains 26 tables in all, together with more than 23,000 calculations, effected on an electronic digital computer to at least one more figure than in the tables themselves, thus ensuring their accuracy All the independent variables are measurable quantities and are given to the limit of measuring accuracy; the dependent variables are given to one more figure than would be required for most practical purposes, and hence impose no accuracy limitations on practical design and development work. Guide-wavelength tables are given for nine sizes of rectangular waveguide and two sizes of circular waveguide, the choice of sizes being directly influenced by current usage. The velocity of light used in the calculations is the most recently accepted value. The mathematical basis of all formulae used in the computations is stated, and comprehensive notes on the use of the tables are incorporated.

Steelmaking for Steelmakers. By A. Jackson, A.Met. (Sheff.), F.I.M., C.G.I.A. 276 pp., 71 illustrations. Published by The United Steel Companies Ltd., 17 Westbourne Road, Sheffield 10. Price: 40/–.

Based on the author's belief that it is increasingly important for all those who are connected with open-hearth melting shops to obtain a comprehensive knowledge of their plant and of the chemistry of steelmaking reactions, this well-written book is intended, as its name implies, for those who have most to do with the actual making of steel.

Simply and lucidly written, the book traces developments in refractories, furnace firing, and control of furnaces by means of instruments. Particular emphasis is laid on the chemistry of the reactions occurring during refining and on securing closer control of analysis and temperature at tapping, while detailed references are made to mould and ladle preparation and to teeming. In addition, an explanation is given of the differences between using feed-ore and oxygen gas for refining the bath, together with an outline of a modern application of oxygen for refining to large open-hearth tilting furnaces and the reasons why this kind of technique must be developed as quickly as possible to enable the open hearth to produce steel of closely controlled quality at production rates which are competitive with those of other oxygen processes.

CHAPMAN & HALL

★ *NEW BOOKS* ★

IMPULSE VOLTAGE TESTING

by W. G. HAWLEY, M.I.E.E.

200 pages *Illustrated* *32s. net*

From John Wiley & Sons Inc.

Handbook of AUTOMATION, COMPUTATION, AND CONTROL

Volume II

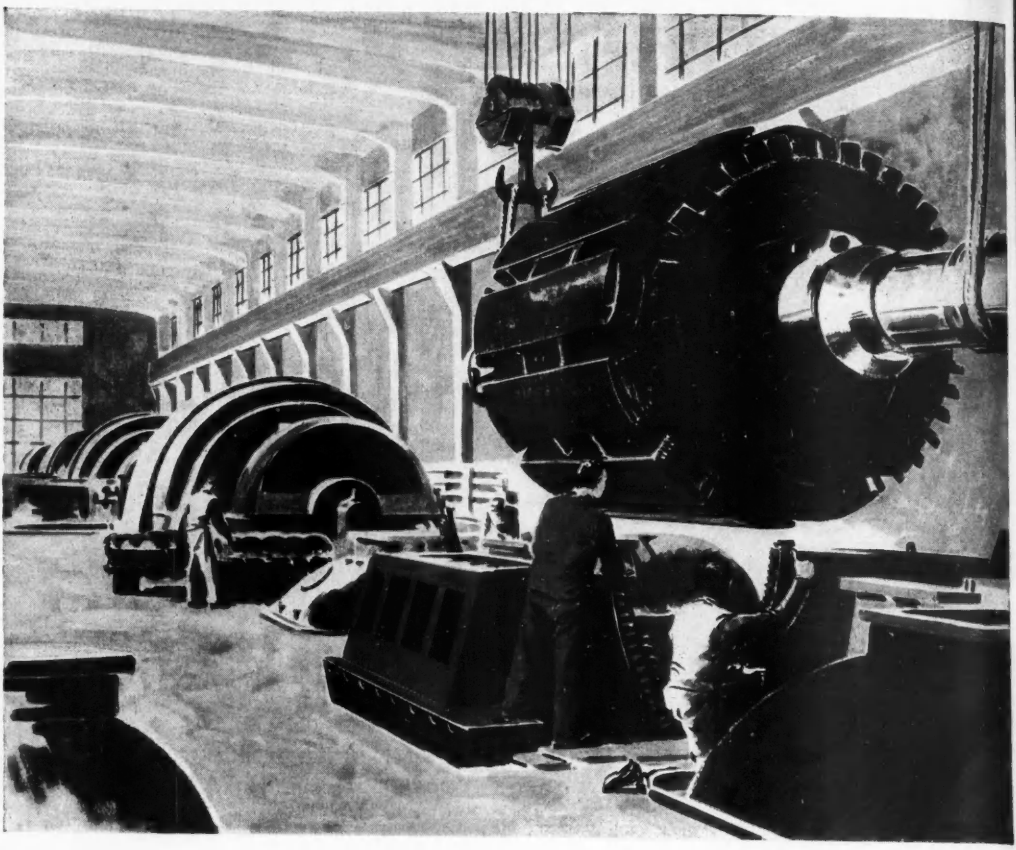
Computers and Data Processing

Edited by

EUGENE M. GRABBE, SIMON RAMO, DEAN E. WOOLDRIDGE

1093 pages *Illustrated* *140s. net*

37 ESSEX STREET, LONDON, W.C.2



Brown Boveri supplied the five alternators for Riddes, owned by the Forces Motrices de Mauvoisin S.A., Sion; with its output of 335 MVA this is the largest hydro-electric plant in Switzerland. Three 60-MVA alternators were also supplied for Fionnay, the upper stage of this power scheme.

Our life each day

is largely dependent upon electricity. Light, power, heat, radio, transport: each of these needs the energy obtained from the country's natural resources. Brown Boveri products assist in exploiting these resources and, by placing them at your disposal, help to raise your standard of living.

BROWN BOVERI

Some of our products: Steam- and gas-turbine plants · machines and equipment for atomic power plants · electrical equipment for hydro-electric and diesel stations · airblast circuit-breakers and transformers for up to 400 kV · protective and regulating systems · mutators · contact converters · electric motors and control gear · electric furnaces · welding equipment · carrier equipment for power system communications · broadcast and telegraphic radio transmitters · television transmitters · transmitting and rectifier tubes · electrical equipment for locomotives, trams, trolley buses · marine propulsion machinery · turbo-compressors · blowers · exhaust-gas turbochargers.

Representatives in most countries.

BROWN, BOVERI & CO., LTD., BADEN (SWITZERLAND)

LATEST INDUSTRIAL LITERATURE

1. **Spinning Lathes.** An illustrated 8-page brochure describes spinning lathes specially designed to withstand the great stress to which such lathes are subjected in modern spinning operations. Principal dimensions are tabulated for lathes ranging from 7 in. to 18½ in. height to centre. Also included are particulars of trimming and beading lathes and of rolling lathes, which are basically the same as the spinning lathes described, but fitted with special slides. A section on accessories is also included.

2. **Alloy Tool Steels.** A range of alloy tool steels consisting of hot-work, cold-work, and shock-resisting steels, as well as carbon tool steels, is presented in a 32-page brochure. In addition to recommendations for the uses of these steels, information on heat treatment is included for each type, and hardness comparison and temperature conversion tables are given.

3. **Self-Locking Nuts.** Developed to meet the needs of a large number of trades, including the motor, aeronautical and light and heavy engineering industries, a range of vibration-resisting self-locking nuts is described in a 4-page leaflet. The nuts have a plastic cap, the addition of which offers a number of advantages for a great many applications; for instance, protruding bolt threads are completely protected against corrosion. Flexibility and freedom from cracking and splintering, as well as easy replacement in the event of damage, are further benefits of the caps, which can be supplied in various colours for identification.

4. **Brush Holders.** Some examples from the enlarged range of brush holders manufactured by a leading firm are illustrated and briefly described in a 4-page leaflet. The brush holders are produced to suit all normal brush sizes in both inch and millimetre dimensions. Clamps and adaptors are available for mounting the holders to almost any size, shape, or position of brush arm.

5. **Pneumatic Indexing Table and Air Chuck.** Designed primarily for use with machine tools, a pneumatic indexing table for drilling, tapping, pressing and milling operations is described in an illustrated leaflet. The table can be hand-, foot-, or electrically operated or automatically synchronized with a machine tool movement, and the standard model will permit indexing of 4, 6, 8, 12 and 24 stations. An additional leaflet describes an air chuck providing a method of holding round, square or hexagonal components accurately whilst being machined. The chuck can be mounted on an angle plate for cross drilling of components, an adjustable stop being fitted to accommodate varying lengths of components.

6. **High-density Polyethylene.** Details are given in an illustrated 20-page brochure of a high-density polyethylene which, unlike ordinary polyethylene, is highly crystalline and is thus a harder and much more rigid material. All accepted methods for processing thermoplastics can be used, and the material has a number of important properties, such as toughness, durability, abrasion resistance, and resistance to water and a wide range of chemicals, oils and greases, which make it suitable for the manufacture of a wide variety of industrial and consumer products.

7. **Gas Turbines.** The smallest in a range of industrial gas turbines is described in an illustrated 24-page brochure. The turbine is a compact two-shaft, open-cycle unit, designed to burn various fuels, and is suitable for driving fixed or variable-speed machinery in industrial, traction, and marine applications. Its advantages include exceptionally small size, simple foundations, wide speed range, few auxiliaries, push-button starting, and a minimum of wearing parts. The unit covers outputs of 2300/3000 hp, and ease of operation is assured by very extensive protection equipment fitted as standard.

8. **Milling and Boring Machines.** The main characteristics of a series of milling and boring machines are given in an illustrated 74-page catalogue, quite outstanding in presentation, which also describes their wide range of applications. By the use of specially designed heads and attachments, machining of the heaviest workpieces can be carried out, with substantial reduction in machining time. Two additional publications are also available, which deal with the machines as turning units and with the machining of workpieces for small-scale production.

9. **Induction Heaters.** An illustrated 4-page leaflet deals in detail with a range of induction heaters of different power output ratings, from 30 to 50 kW maximum continuous output. The heaters are particularly recommended for supplying the R.F. power for machine-tool slideway hardening and a great variety of other surface-hardening applications, using a patented intensifier and associated equipment. Typical intensifiers are illustrated to show the wide variety of forms which are being effectively hardened with this equipment. Additional similar leaflets are available on induction heaters of lower power ratings for applications in a large number of industries.

10. **Precision Forging Machine.** Details are presented in a 6-page illustrated leaflet of a precision forging machine basically developed for use with round workpieces, though, with special attachments, workpieces of polygonal shape, splined shafts, etc., can also be produced. The finished shape of the workpiece is governed by means of stops and templates, making it possible to produce a range of different forgings with the same set of tools. Control is automatic and effected hydraulically. The dimensional accuracy of the finished forging is an outstanding feature of the process, other advantages of which include very short forging times and cheap tooling.

11. **Oxygen Profiling Machine.** Details are given in a 2-page leaflet of an oxygen profiling machine, in which all that is required is a simple pencil line drawing of the workpiece to approximate finished size. The machine can be set to compensate automatically for width of cut and thus, in the same way, correction of small overall dimensional inaccuracies in finished profiles is possible. The machine is entirely self-contained and is suitable only for single-phase a.c. electrical supply, consumption being approximately 500 W.

12. **Universal Tool and Cutter Grinders.** A range of universal tool and cutter grinders is presented in an illustrated 24-page brochure. The machines are suitable for grinding all kinds of carbon, high-speed steel, and carbide-tipped tools. One of the models is particularly suitable for grinding carbide-tipped tools for lathes and planers, correct and efficient grinding of the chip-breakers on these tools, cutting-off carbide tool tips, grinding carbide-tipped milling cutters, reamers, etc. A section deals extensively with accessories for the machines, and some illustrated examples of set-ups are included.

MAIL THIS COUPON TO-DAY

THE ENGINEERS' DIGEST, 12.59
120 Wigmore Street, London, W.1

Date.....

Please send free and without obligation the literature indicated by the following circled numbers:

1 2 3 4 5 6 7 8 9 10 11 12

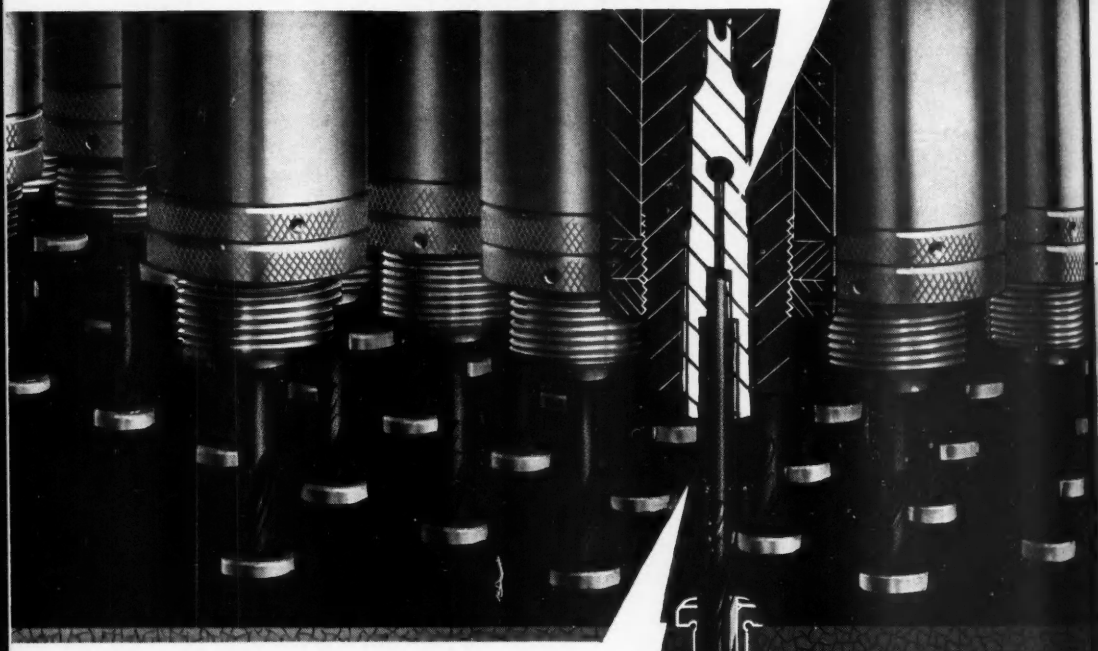
Name .....

Position .....

Company.....

Address .....

ANOTHER DORMER ECONOMY



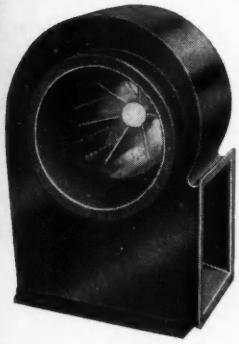
or repetitive drilling of any particular size of hole, where a taper drive
: required, considerable savings can be effected by using a DORMER
Conversion Sleeve and straight shank drills with tang. One sleeve
utlasts numerous drills—replacement straight shank jobber drills are
heaper than those with taper shanks.
Additionally this drive permits drilling to much closer centres than with
ne conventional straight shank drill chucks—more holes can be drilled
multaneously.
. comprehensive range of DORMER Drills are available with tanged
raight shanks.
escriptive brochure available.

HE SHEFFIELD TWIST DRILL AND STEEL COMPANY LIMITED
IEFFIELD **ENGLAND**

ORMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS

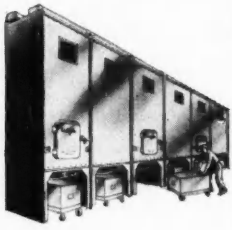
CONVERSION SLEEVES AND TANGED STRAIGHT SHANK DRILLS

industry needs "Airflo"



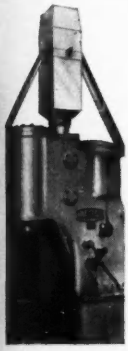
FANS

The "Resista" P.V.C. Fan is impervious to the chemical action of strong acids, alkalis and moist gases. It is the fan that in conjunction with P.V.C. Hoods and Ducting has provided industry with the greatest step forward in chemical fume handling.



DUST COLLECTION

"Airflo" 'E' Type Dust Collecting Unit. For dry non-fibrous, non-explosive dusts with air temperature not exceeding 160°F. Fully automatic shaking device. Made on unit principle.

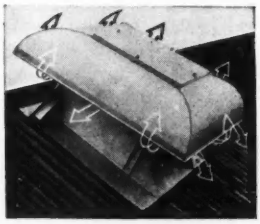


INDUSTRIAL SILENCING

Where noise creates problems as with Pneumatic Hammers, High pressure blowers, Air noises on Dust and Fume Plants, especially during night shifts the purpose designed "Airflo" Industrial Silencer provides the easy solution. Simple to install. No loss of production efficiency.

POWERED ROOF VENTILATOR

"Airflo" Powered Roof Ventilator. Fits any roof angle. Light enough for corrugated iron roof. *Positive* ventilation under all conditions. Unit despatched completely assembled. Prices from £29 15*s*.



WELDING TABLE

"Airflo" Welding Table — the perfect working surface for welding, brazing and soldering. Fumes drawn away from operator. Supplied complete with motorised unit.

SEND NOW

for literature dealing with "Airflo" products. If you have any ventilating or dust collecting problems tell us about them. Our technicians can help you.

"Airflo" TRADE MARK

Industrial Fan & Heater Co. Ltd

"Airflo" WORKS, BIRMINGHAM, 11. Phone VICtoria 2277

And at LONDON, MANCHESTER, SWANSEA.

A Member of the SIMMS Group of Companies.

The MINIDIGEST

Utilizing induction heating to soften work-pieces as they approach the cutting head, a new "**hot-milling**" **process,** developed in the U.S.A. by the Cincinnati Milling Machine Company, is believed to provide an answer to a number of the problems associated with the machining of very hard metals. As an example of the efficiency of the process, it is stated that, by keeping the temperature of the cutting point between 950 and 1000°F, a steel of 550 Brinell hardness can be milled at a speed of 550 sfpm with carbide tools, as compared with a maximum of about 40 sfpm for an equivalent tool life with steel tools by conventional cold-milling methods.

* * *

Closed-circuit television is finding increasing applications in industry, one of the most recent being reported in *Mashinostroitel* for August 1959. This application involves the use of **closed-circuit television in a completely remote-controlled vacuum-casting plant** being installed in Russia, in which, during casting, specially constructed air-cooled television cameras record the level of the molten steel in the casting ladle and also details of the liquid-metal stream passing from the ladle to the ingot moulds. The cameras are connected to television receivers in a separate control cabin, from which casting operations are directed by hydraulic control equipment.

* * *

A method of **producing molybdenum metal powder by the rapid single-stage reduction of molybdenum oxide** at high temperatures has been developed in the U.S.A. by Metals and Residues, Inc. It is estimated by the company that the production of molybdenum powder can be increased by a factor of from 5 to 8 by means of this process.

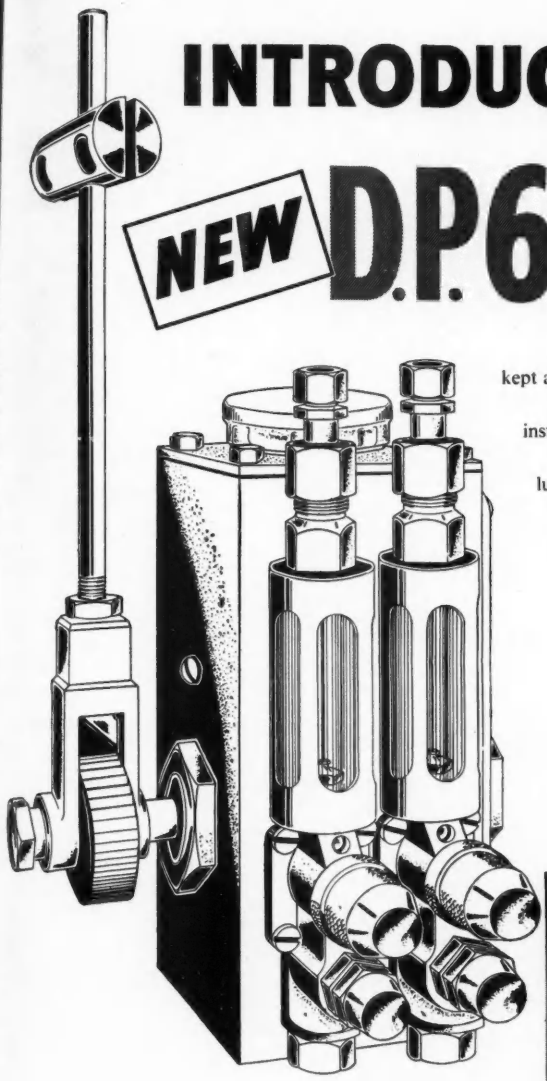
* * *

Fundamental studies carried out at Kyoto University in connection with the **relationship between the period of exposure to ultra-violet light and the transparency of photo-sensitive glass** show that opacity does not necessarily increase progressively with exposure. Thus, the report (in *Yogyo Kyokai Shi*, August 1959) points out that, when glass specimens, 2 mm in thickness, containing about 81% silica, 12·5% lithia, 2·5% potash, 4% alumina, 0·03% ceria, and 0·027%

tresco
DROP FORGED
STEEL VALVES
Designed and manufactured to B.S.2995: 1958 and also to American standards and codes of practice, Tress valves undergo full inspection and test control throughout each stage of production
Valve engineering of the highest order ensures that these valves, like all Tress valves, will give trouble free performance. Valve maintenance is greatly reduced, and Tress valves give greater efficiency at a reasonable cost.
Tress Engineering Company Limited
WORKS: NEWBURN, NEWCASTLE UPON TYNE, 5.
TELEPHONE: LEMINGTON 67-4172/3
London: 30a Sackville St., London, W.1. Phone: REGent 8886/7

INTRODUCING THE

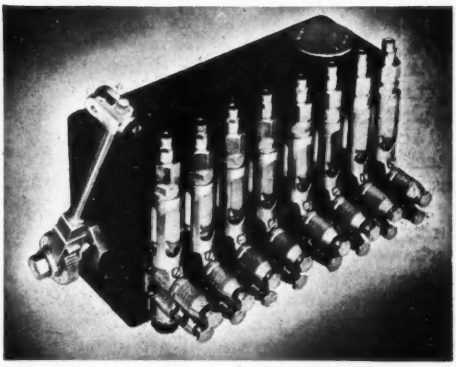
NEW D.P.60 MECHANICAL LUBRICATOR



During the last 60 years, Wakefield lubricators have kept abreast of the changing needs of industry. The DP 60 represents the experience of these years. It is an instrument of precision for feeding oil against pressures up to 1000 p.s.i. It can be operated by the plant it lubricates on reciprocating or rotating drive. The flow of oil is automatically controlled by the 'start-up and cut-off' of the machine. Efficient lubrication is combined with economy in oil consumption.

ADVANTAGES OF THE DP 60

Welded steel construction gives strength with low weight ratio.
Each feed can be regulated independently.
Complete pump unit can be removed and replaced in one assembly.
Patented quick release cap minimises oil contamination.
Up to 32 feeds can be fitted.
Large oil reservoir ensures long working periods between topping-up times.
Built-in perspex oil gauge on the oil reservoir.



WAKEFIELD
INDUSTRIAL LUBRICATORS

Ask for our DP 60 booklet. Send us the coupon and we shall be pleased to mail you a copy with full DP 60 details — by return of post.

FLEASE SEND ME A COMPLIMENTARY COPY OF THE DP 60 BOOKLET

To: Dept. PD Wakefield-Dick Industrial Oils Ltd.,
Castrol House, Marylebone Road, London, N.W.1

NAME.....

ADDRESS.....

.....

E)

The MINIDIGEST

gold, were exposed to ultra-violet light for 1000 min and then heated to their softening temperature, it was found that opacity first increased steadily with irradiation times up to 30 min, but then decreased until, after a 180-min exposure, they became completely transparent, although their colour was changed to a deep red. Between 180 and 1000 min, however, they again became progressively more opaque.

* * *

An extremely simple and economical process for **producing very narrow slots in copper tubing** of such uniformity that fins and blades can be brazed in place without alignment jigs has been developed by the U.S. Naval Research Laboratories. As reported in *Product Engineering* (October 19, 1959), the slots in the copper tubing are first machined slightly oversize, and the tubing is then forced through a die, narrowing the width of the slots to the required dimension. For example, in a typical application, slots are cut with a 0·008-in. circular saw and are then compressed in the die to 0·001 in. The technique was originally developed for producing microwave tubes, but a much wider range of applications is envisaged.

* * *

An article in *Kunststoffe* (November 1959) is concerned with the **creep-rupture strength of plastic pipes** made of polyvinyl chloride and of polythene. It is pointed out that extensive research work has established the possibility of being able to determine maximum permissible stress values in terms of the period during which such pipes are exposed to high mechanical loads, e.g., internal pressure. The long-term behaviour of these plastic pipes is discussed, together with details regarding methods of counteracting this tendency to lower permissible stress as a result of prolonged periods of exposure to high mechanical loads in service.

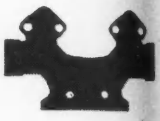
* * *

Stated to overcome the disadvantages of existing methods of **continuous measurement of reduction in gauge in the temper rolling of strip** by comparing the speeds of the strip before and after rolling, a new method, developed by the British Iron and Steel Research Association,

HIGH-DUTY S.G. NI-RESIST Alloy Iron Castings and Components

If you need a casting or component for a difficult or highly specialised application, pass your problems to the John Williams Foundry Division — they'll do the rest.

THIS turbo blown diesel engine exhaust manifold, cast in S.G. Ni-Resist alloy iron, stands up to extremely high working temperatures.



A COMPLETE TECHNICAL AND FOUNDRY SERVICE

Backed by advanced research laboratory facilities. For a consultation—without charge or obligation—or a copy of our technical booklet "Sound and Solid Castings"—write to:—

JOHN WILLIAMS OF CARDIFF LTD

EAST MOORS ROAD, CARDIFF Tel: Cardiff 33622 (12 lines)
Telex 49303

Water in your air lines?

VICTOR CAN HELP!

Please write for Booklet No. C. A. 100 to

VICTOR PRODUCTS (WALLSEND) LTD.,

WALLSEND-ON-TYNE

y
n
ngs
ents

u need
sting or
onent for
ficult or
lication,
the John
the rest.

facili-
ge or
ooklet

F LTD
(12 lines)

EST

her gas turbines of the PERKINS range

55 h.p. TITAN
Constant and variable speed versions for one-man helicopters and flying platforms.

170 h.p. T-150
Constant speed for electric generators, compressors and pumps.

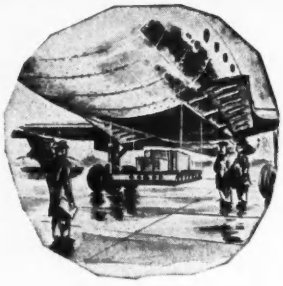
500-600 h.p. JUPITER
Constant speed for electric generators, compressors and pumps. Variable speed for marine propulsion. Air-bleed for aircraft engine starting.

1100-1250 h.p. SATURN
Constant speed for electric generators, compressors and pumps. Variable speed for marine propulsion.

The MARS is made under licence from Solar Aircraft Company, San Diego, California, U.S.A. The TITAN, T-150, JUPITER and SATURN are engines designed by Solar, of which the TITAN and T-150 are under advanced development and all versions of the JUPITER and SATURN are in production at San Diego. Perkins Gas Turbines Limited is Solar's distributor for these engines.

PERKINS GAS TURBINES LIMITED,
Subsidiary of F. Perkins Limited
PETERBOROUGH, ENGLAND.
Telephone: Peterborough 5341

Perkins Gas Turbines

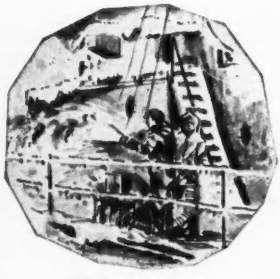


Auxiliary Power Units

Fire Fighting

Emergency Electric Generating Plant

Portable Compressor Set



De-icing Equipment

The British-built Perkins MARS Gas Turbine

* **Continuous rating 50 h.p.**
* **Operates equally well on diesel fuel, paraffin or low grade petrol.**
* **Free of vibration with no reciprocating parts. Requires no additional cooling.**
* **Designed for instant hand starting, reliability, ease of handling (weighs only 98 lb), and minimum maintenance.**

Some typical applications include:—portable pumps 500 g.p.m. at 100 p.s.i.g., with 10 ft suction lift for fire fighting, salvage, etc., fresh or sea water, also transfer of fuels—electric generator sets—de-icing—instructional sets—bleed air requirements—compressor sets—packaged power plant—exhaust heat combined with shaft power for process industries. The MARS Gas Turbine will be ON SHOW on Stand No. K.3., West Brompton Entrance, National Boat Show, Earls Court, London, Dec. 30—Jan. 9.

✱ SEND IN THE COUPON BELOW FOR FULL DETAILS

To Sales Division (Dept. E.D.)
Perkins Gas Turbines Limited, Peterscourt, Peterborough, England

I/We are interested in receiving details of the Perkins MARS Gas Turbine for

NAME .....

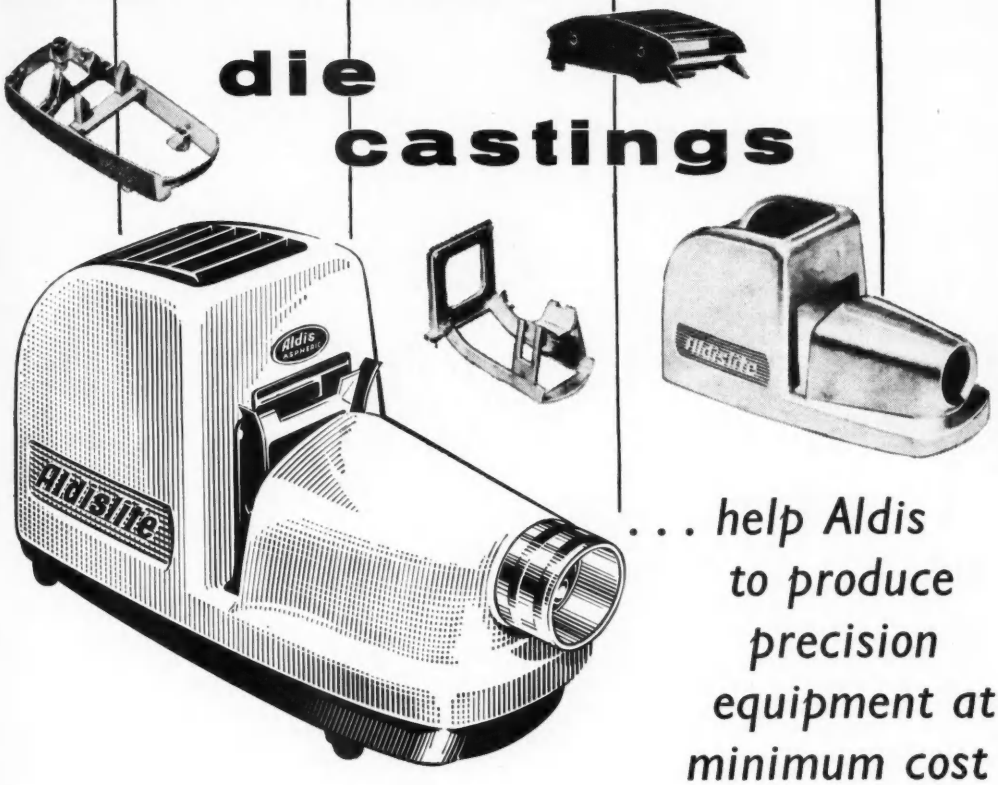
COMPANY .....

ADDRESS .....

.....

WOLVERHAMPTON

die castings



. . . help Aldis to produce precision equipment at minimum cost

Precision, strength and high quality finish—these are the prime requirements of Aldis Brothers Ltd. for their Aldislite Slide Projector.

WOLVERHAMPTON die castings meet these requirements, in the largest and most modern plant in the country, backed by nearly half a century's experience in the making of quality die castings.

THE WOLVERHAMPTON DIE CASTING CO. LTD.

Graiseley Hill Works, Graiseley Hill, Wolverhampton.
Telephone: 23831/6.

Half a million square feet devoted to the production of better die castings.

The MINIDIGEST

makes use of two photo-cells sited on two illuminated spots on the strip surface, the two spots being a fixed distance apart and lying along the pass-line. Small irregularities in the light reflected from the strip surface give rise to a pattern in the output of the first photo-cell and, after an interval of time which depends on the distance between the two photo-cells, another similar pattern appears in the second cell. If the output of the first cell is delayed, e.g., on a tape-recorder, and is then added to the second cell signal, a maximum combined output is obtained when the delay time introduced is equal to the time for the passage of a point on the strip surface between the two cells. From this delay time and the known distance between the illuminated spots, the strip speed can easily be calculated.

* * *

Research undertaken by Edgerton, Germeshausen and Grier, Inc., of Boston, Mass., indicates the possibility of **increasing the speed and sensitivity of photographic emulsions by strong electric fields.** Tests have already established that the use of such fields can bring about a marked increase in the speed of existing emulsions, and it is considered likely that sensitizing substances, capable of increasing speed still further, can be found. It is also considered likely that special emulsions can be developed which become sensitive to light only when an electrical pulse is applied, thus producing, in effect, a " built-in " electrical shutter.

* * *

Details of the so-called **" shaking ladle "** and its use for different metallurgical operations are given in an article in *Jernkontorets Annaler* (No. 8, 1959). Developed in Sweden, the shaking ladle makes it possible to obtain very intense mixing of the molten iron and to ensure intimate contact between it and solid or gaseous agents. Interesting results have already been obtained in the desulphurization of pig iron, carburization with coke breeze, alloying with silicon and manganese, and preblowing with oxygen for removal of silicon and vanadium. In short, the shaking ladle should be extremely useful in all cases where a good stirring effect is required, e.g., in foundries, where it can be used in combination with an acid cupola, and in steelworks, where it is simpler to use than the rotating furnace normally employed for desulphurization.

INDUSTRIAL LUBRICANTS

GREASES, GREASE COMPOUNDS

and Molybdenum-Disulphide (MoS_2) Specialities

Make this simple test—

and this

Prove for yourself by placing a small amount in an ordinary refrigerator—or hold over a flame.

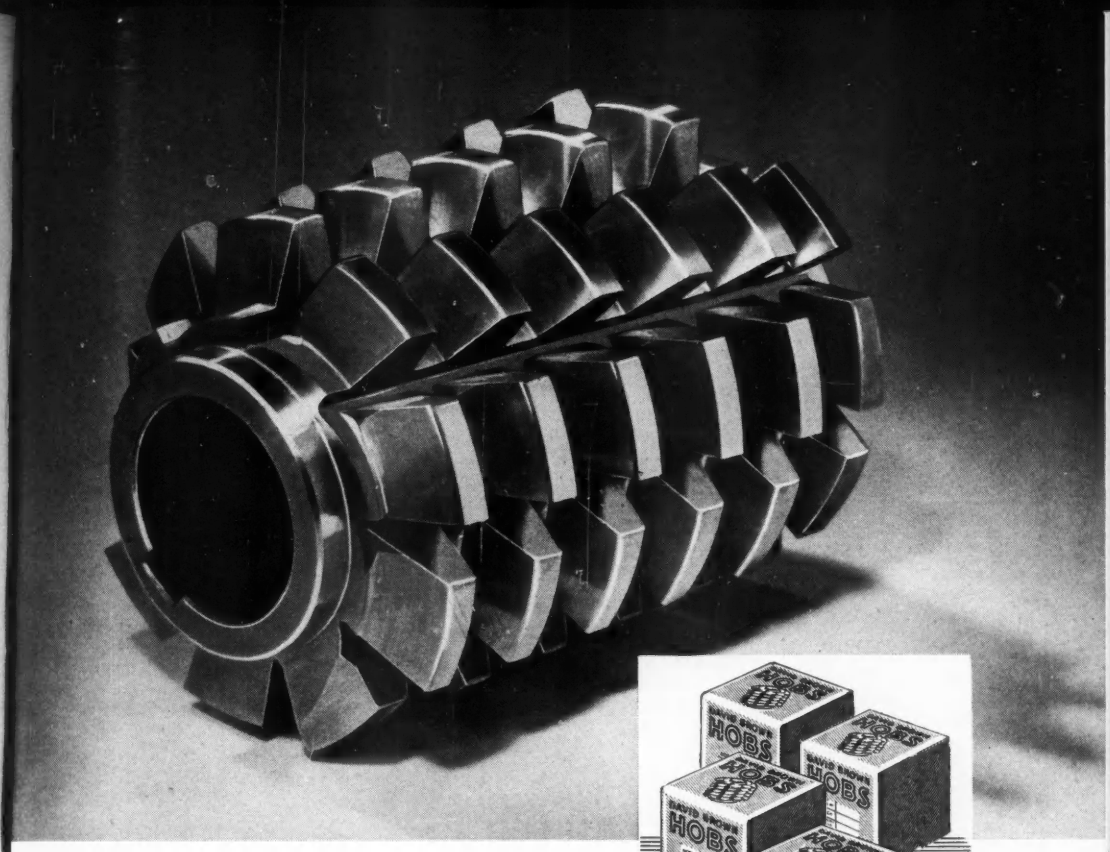
Ask for a free sample and mention your lubrication problem.

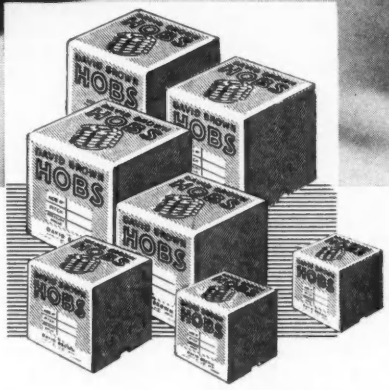
JET-LUBE LTD.

PARK LANE, FALLINGS PARK, WOLVERHAMPTON

TELEPHONE: WOLVERHAMPTON 31295

London: 26/32 Caxton Street, Westminster, S.W.1.





A Whole Life Policy

David Brown, in selling you a batch of Precision Hobs, or even a "one off," are not intent on just getting off the order book and on to an invoice. They are concerned that their products should give of their best. *throughout their whole life.*

To ensure that this happens David Brown maintain the most comprehensive heat treatment batch and individual inspection procedures—each stage the sole responsibility of a craftsman.

Remember—when you order from David Brown you are calling on nearly a century's accumulated experience. Remember—David Brown for precision Hobs.

DAVID BROWN

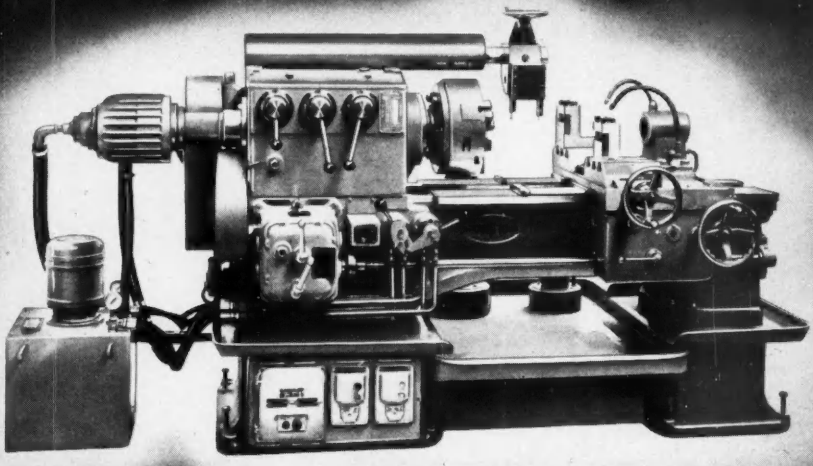
THE DAVID BROWN CORPORATION (SALES) LIMITED

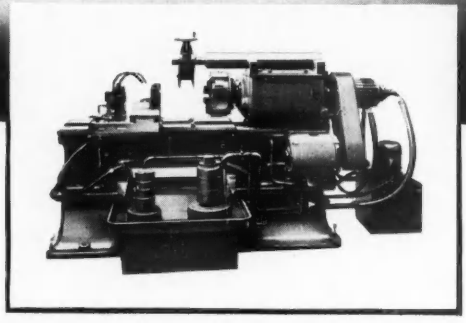
TOOL DIVISION · PARK WORKS · HUDDERSFIELD · TEL. HUDDERSFIELD 3500

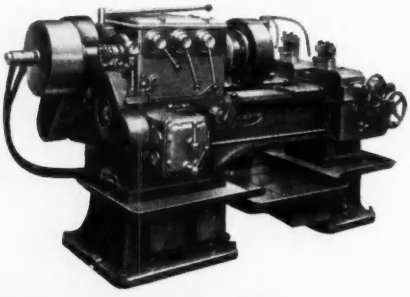
O.A. 5780

CROWTHORN

8½" CENTRE PARTING-OFF TURNING & BORING LATHE







This lathe is specially designed for the high speed production of such articles as cylinder liners, piston rings, etc., and for the rapid parting-off of ferrous and non-ferrous bar and tube. The specification includes pneumatic or hydraulic chucking equipment, screw operated parting-off toolslide assembly on overhead arm, front and rear tool holders, boring bar holders, self-contained motor drive and electric suds pump. Please write for detailed literature.

CROWTHORN ENGINEERING COMPANY LIMITED

High Class Machine Tool Makers

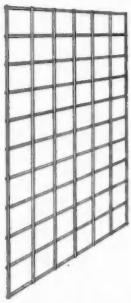
REDDISH · STOCKPORT · ENGLAND

Phone: STOCKPORT 7271-2-3 *Grams: CROWTOOL, REDDISH*

CL.92

Weldmesh in use

...for mechanical handling



Weldmesh is the ideal material for retaining smaller components in post pallets and for racking, partitioning or machinery guards, etc. Cut it to the shape you want—it holds together because it is welded together. In the Weldmesh list of standard sizes you will find a mesh size and wire gauge to suit every purpose. A technical service is available to handle any problems.

Weldmesh is a registered trade name and is supplied direct to users by the sole manufacturers :

THE B.R.C. ENGINEERING COMPANY, STAFFORD

London, Birmingham, Bristol, Leeds, Leicester, Liverpool, Manchester, Newcastle, Cardiff, Glasgow, Dublin, Belfast, Bulawayo, Calcutta, Johannesburg, Singapore, Vancouver.

Export Sales : 54 Grosvenor Street, London, W.1

M-W931

CROWN WHEEL FORGINGS

for the Rear Axle of the

ALL-NEW FORD ANGLIA

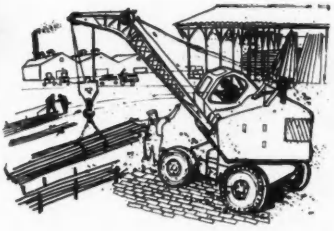
are supplied by

FIRTH-DERIHON

SHEFFIELD & DARLEY DALE

High Quality Drop Forgings for the Automobile and Aircraft Industries

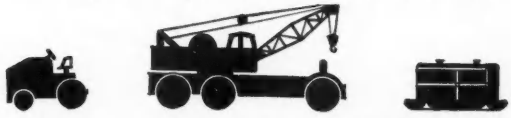
THE FIRTH-DERIHON STAMPINGS LIMITED · SHEFFIELD



POWER for industry

Our range of industrial engines are a practical proposition for many types of industrial equipment ... **compressors, cranes, pumps, contracting equipment, earth borers, generators, railcars, welding plant, works trucks, tractors and conversions.** Simple design, modern flow-line production methods and common interchangeable parts contribute to the low cost of these high efficiency engines. And remember, every engine is fully backed by a World-wide Parts and Service Organisation. Take your choice from a wide power range ... Diesel 20 to 86 b.h.p. and Petrol 11 to 87 b.h.p. (12-hr. rating).

DIESEL ECONOMY—have you considered the replacement of existing power units in your equipment and trucks with the famous 4D Diesel engine? You'll have the unique advantages of economy, long-life and low running costs ... plus the best service in the World!



Wherever you are, whatever your problem,

FORD

MOTOR COMPANY LIMITED · ENGLAND

are at your service

For further details of our

INDUSTRIAL ENGINES

and the equipment they power, send the coupon to your nearest Ford Dealer or direct to

Please send me technical brochures of your *PETROL/DIESEL Industrial Engines. The maximum B.H.P. required is.....at.....R.P.M. Also, please send details of the following equipment powered by your engines.

.....

.....

Name .....

Address .....

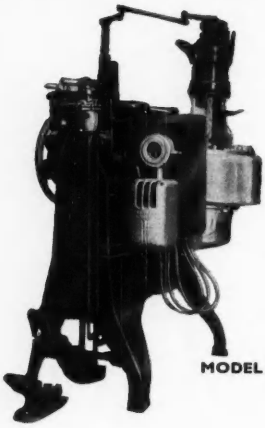
.....

Nature of Business.....

.....**Telephone No.**.....

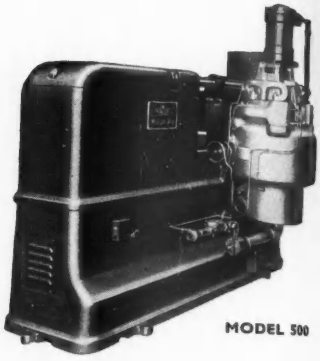
** Delete where not applicable* G51·24·12

FORD MOTOR COMPANY LTD · PARTS DIVISION (G51) · AVELEY DEPOT · SOUTH OCKENDON · ROMFORD · ESSEX · ENGLAND



MODEL 215E

A shot every moment
—cast well and true,
with production improvement
means business for you

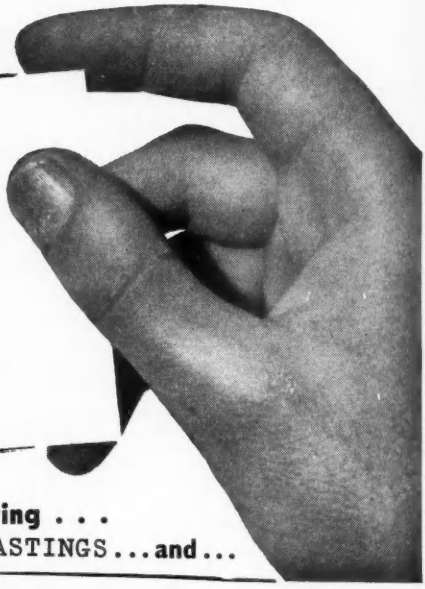


MODEL 500

TELEPHONE CARLISLE 21418

Coulthard Madison Kipp

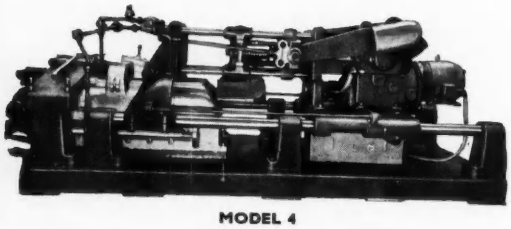
ENGINEERING DIVISION
DURRANHILL ROAD
CARLISLE



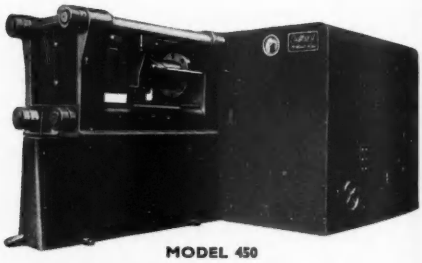
— signifying . . .
LIFETIME QUALITY DIECASTINGS . . . and . . .

hi-high

PRESSURE DIE CASTING MACHINES



MODEL 4



MODEL 450

PRODUCTION'S MUCH FASTER WITH A COULTHARD-KIPPCASTER.

SPECIAL STEELS
for die casting dies

Photograph by courtesy of J. V. MURCOTT LTD. Castings 7¾lbs. each produced at intervals over 3 years

DIES & DIE INSERTS

(KE) **A 145** 5½% Chrome Vanadium Molybdenum Steel.

(KE) **X 369** 5½% Chrome Tungsten Molybdenum Steel.

(KE) **896** Medium Carbon Chrome Vanadium Steel.

Supplied in ultrasonically tested forged blocks and black bars of square, round and rectangular sections.

DIE CORES

(KE) LOCK **237** 18% Tungsten Vanadium High Speed Steel or the same quality of steel as that used for the die. Supplied centreless ground to precision limits, in lengths.

EJECTOR PINS

(KE) **896** Medium Carbon Chrome Vanadium Steel and other types.

Supplied centreless ground and in the annealed condition, suitable for upsetting of the ends.

UNCOATED WELDING FILLER RODS

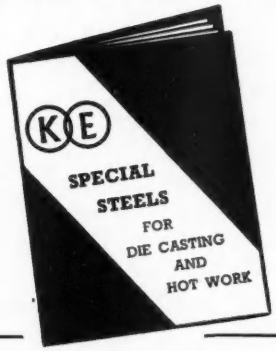
(KE) **A 145** 5½% Chrome Vanadium Molybdenum Steel.

(KE) **X 369** 5½% Chrome Tungsten Molybdenum Steel.

5/32" diameter material, in 3 feet lengths, available from stock.

Especially suitable for atomic welding under hydrogen.

This booklet, giving greater detail, is available free on request.



KAYSER ELLISON & CO. LTD

CARLISLE STEEL WORKS · SHEFFIELD

TELEPHONE: SHEFFIELD 22124

ESTABLISHED 1825

Midland Stock Warehouse
Station Road, Coleshill, Birmingham. Tel. Coleshill 2041/2

London Stock Warehouse
4 Pembridge Mews, W.11 Telephone BAYswater 9131/2

ARCHDALE

HYDRAULIC PRE-SELECT

for greater operating speed –faster penetrating capacity

Photograph by courtesy of
OTIS ELEVATOR CO. LTD

JAMES ARCHDALE & CO. LTD.

Registered Office:
LEDSAM STREET, BIRMINGHAM, 16
Telephone: EDGbaston 2276

Works:
BLACKPOLE WORKS, WORCESTER
Telephone: Worcester 27081 (6 lines)

Sole Selling Agents: ALFRED HERBERT LTD., COVENTRY · Telephone COVENTRY 89221

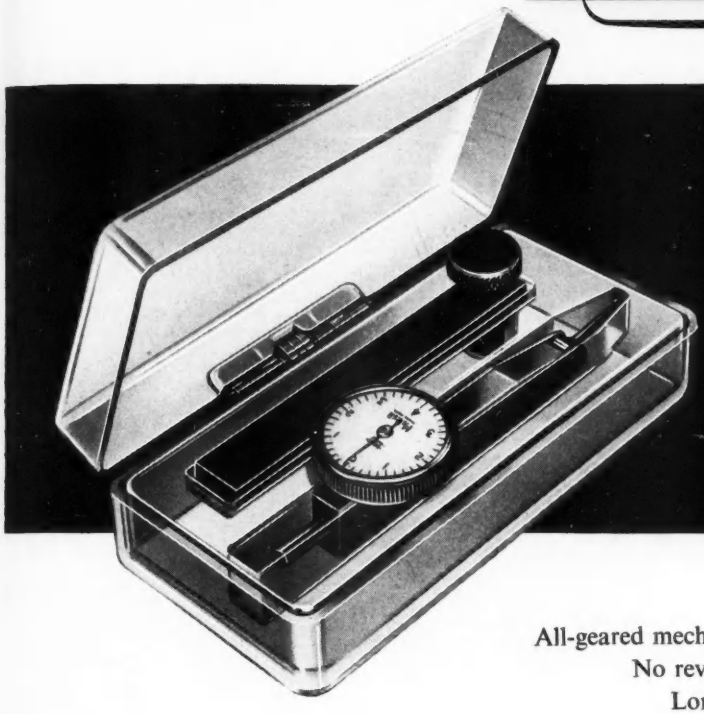
A Member of the Staveley Coal and Iron Co. Ltd Group

CNLY

introducing the

MERCER

300



a new lever type dial test indicator with unique features

All-geared mechanism for sensitivity
No reversing lever required
Long stylus as standard
0.08 in. dia. ball
Frictionless bearings
Wide range of attachments available
Readings 0.0001 in. and 0.0005 in.
0.002 mm. and 0.01 mm.

ONE HUNDRED YEARS OF FINE MEASUREMENT

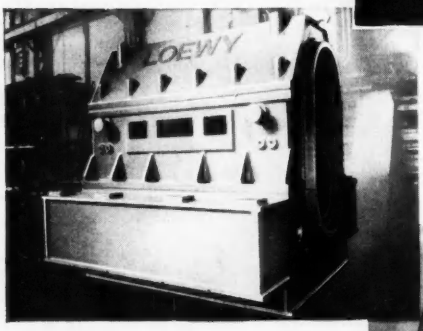
THOMAS MERCER LIMITED

of St. Albans, Hertfordshire. TELEPHONE ST. ALBANS 55313

MP 2507

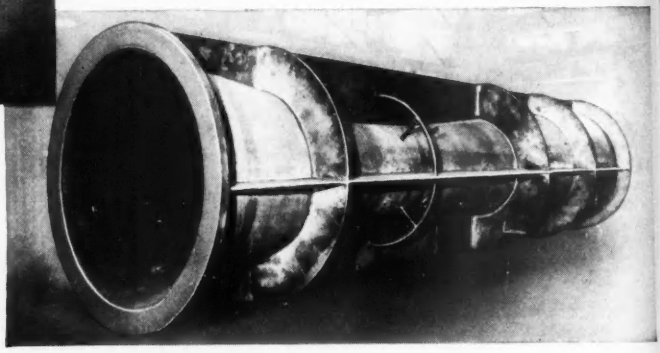
Heavy Welded Fabrications

For the ultimate in Welded Fabrications consult Empyrium, pioneers in this field.



Transformer and Switchgear Tanks; Storage Tanks for Petrol, Oil and Water; Autoclaves; Chemical Plant of all descriptions; Bedplates; Machine Tool and Press Frames; Gas Works Plant; Hoppers, Condensers, Gear Guards, Blast Mains, Air Receivers and Pressure Vessels of all types.

Empyrium fabricate for all industries to ASME and Lloyds specification. Also to the exacting requirements of the Petroleum and Oil Companies. Full testing facilities, including X-Ray.



EMPYRIUM
WELDING & MANUFACTURING COMPANY LIMITED

Head Office and Main Works: Pritchett Street, Birmingham 6.
Telephone: ASTon Cross 3203/4/5.
Telegrams: Empyrweld Birmingham.

PIONEERS IN WELDING PRACTICE SINCE 1917

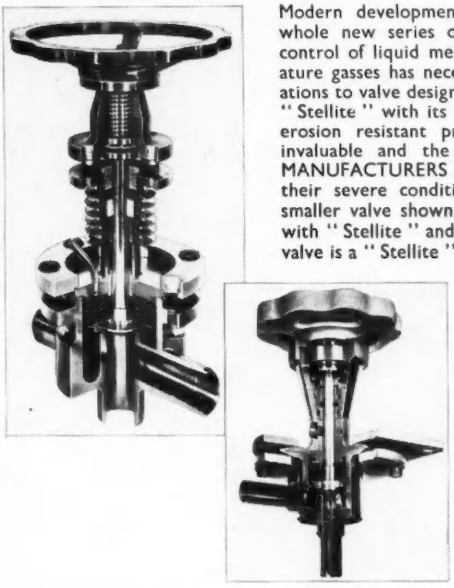
JW. Ad 4680

"STELLITE" ALLOYS

for heat, abrasion, corrosion and machining problems

Typical applications of "Stellite"

LIQUID METAL VALVES PROTECTED WITH "STELLITE"



Modern developments have presented a whole new series of problems, and the control of liquid metals and high temperature gasses has necessitated drastic alterations to valve design.
" Stellite " with its high temperature and erosion resistant properties has proved invaluable and the majority of VALVE MANUFACTURERS specify " Stellite " for their severe conditions of service. The smaller valve shown has a plug hardfaced with " Stellite " and the plug on the larger valve is a " Stellite " precision casting.

Illustrations by permission of Palatine Tool and Engineering Co. (Surbiton) Ltd., Surbiton, Surrey

WRITE FOR PUBLICATION SP18.
"Deloro Stellite in the Chemical & Petroleum Industries"

AD. No. 286-A.

or send for details of "Stellite" in your particular industry

DELORO STELLITE

DELORO STELLITE LIMITED · HIGHLANDS ROAD · SHIRLEY · SOLIHULL · WARWICKSHIRE
DELORO STELLITE DIV. OF DELORO SMELTING & REFINING CO. LTD. BELLEVILLE · ONTARIO · CANADA

Testing a 40" Hypoid Gear and Pinion for a Pulper, photo by courtesy of Black Clawson International Ltd.

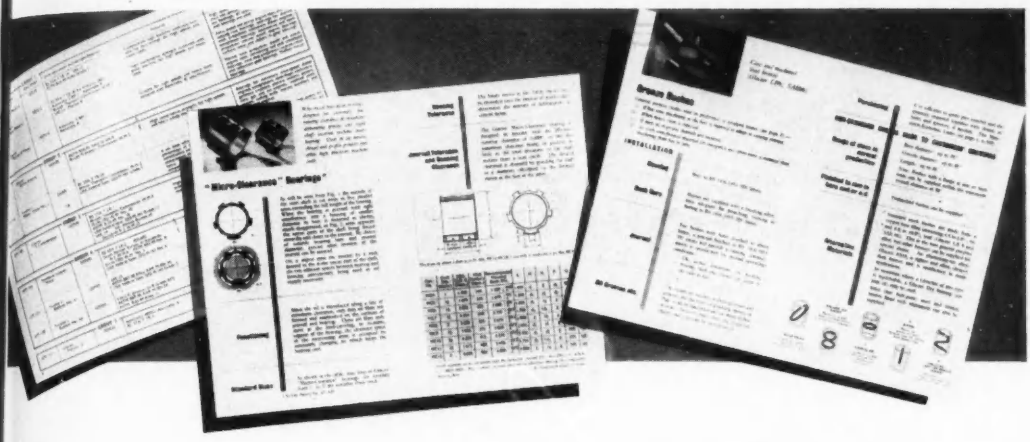
Spiral Bevel and Hypoid Gears from 1" to 72"

Spiral Bevel and Hypoid Gears offer many advantages for right angle drives where high efficiency, smooth and silent running are required. E.N.V. specialize in the design and manufacture of straight and curved tooth bevel gears. They offer collaboration with engineers from the project stage on the design of gears and mountings. They have unique facilities for the large-scale manufacture of transmissions including final drives, differentials and axles for vehicles and agricultural equipment, precision gears for aircraft and gears for industrial applications.

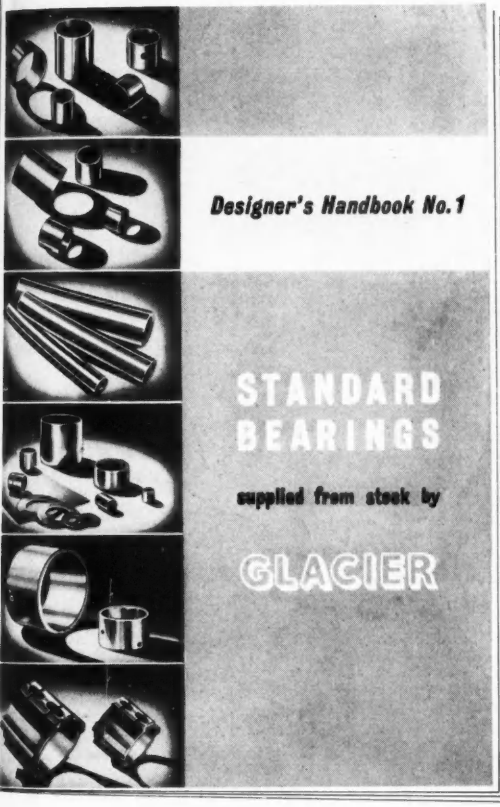
ENV *for gears*

E. N. V. ENGINEERING COMPANY LIMITED *HYTHE ROAD, WILLESDEN, LONDON, N.W.10*

AP56



Don't waste another minute — *get hold of this book!*



The Glacier Designer's Handbook should be in the hands of every draughtsman.

With it the drawing of Plain Bearings becomes quite unnecessary: it is sufficient to quote a part number.

It will save you pounds' worth of time and trouble! GLACIER Designer's Handbook No. 1 deals with STANDARD BEARINGS.

It provides (a) *Complete technical data* on fits, finishes, tolerances, housing diameters and clearances; advice on assembly, operating conditions etc; (b) *Tables of standard sizes* of machined bronze bushes, wrapped bushes, dry bearings and bearing materials — all of which are available from stock on quotation of a single part number.

GLACIER Designer's Handbook No. 1 is first of a series designed to save designers time.

FREE OFFER: We will send to any company, on receipt of a request from an official of the company, a copy of the GLACIER Designer's Handbook No. 1 for each of their draughtsmen.

WE WILL ALSO SEND A COPY TO ANY INDIVIDUAL DRAUGHTSMAN WHO WRITES TO US ON HIS COMPANY'S LETTERHEADING.

Write *now* to:

GLACIER

THE GLACIER METAL COMPANY LIMITED · DEPT. 4 · ALPERTON · WEMBLEY · MIDDLESEX

HERE is a method that takes full advantage of the unique capacity of Hicycle for *constant speed under load.* A gang of Hicycle machines is shown being fed forward by air feed-cylinders, *drilling 17 holes in a total time of 12 seconds* in the arched roof support of a railway coach. Total saving in labour costs? Over 75%! Hicycle tools have a virtually indestructible squirrel-cage motor and, since they run at a working pressure of 125 v—72 v to earth—are very safe. Ask for catalogue 54 and leaflet SP.439.

The operator is shown drilling the vertical holes with a Hicycle drill mounted in a radial arm after the horizontal holes have been completed.

Automation "Gang" Drilling with Hicycle

ELECTRIC PRODUCTION TOOLS

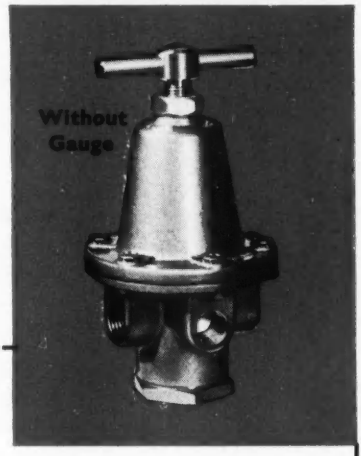
MANUFACTURED BY Consolidated Pneumatic

CONSOLIDATED PNEUMATIC TOOL CO. LTD · DAWES ROAD · LONDON · S.W.6

Schrader's NEW AIR PRESSURE REGULATOR

The latest addition to the Schrader range of outstanding air control equipment.

Uniform air pressure is essential to efficient pneumatic operating and to the maintenance of economical running costs. Those variations in airline pressure which result from demands on the line, distance from the compressor and the frequency of compressor cut-out can be smoothed out with the Schrader Pressure Regulator. And where main airline pressure is higher than needed it can be reduced to actual requirements at any point and kept constant. Inlet pressures of up to 250 p.s.i.g. can be regulated down to a range of 5–125 p.s.i.g. The Schrader Regulator offers, size for size, a higher capacity, faster response, lower pressure drop under loading than any other. Let us tell you how this Pressure Regulator could work for you. Send the coupon today for further details.



Schrader **AIR PRESSURE REGULATOR**

To: **A. SCHRADER'S SON**, Air Control Products Dept. ED,
829 TYBURN ROAD, ERDINGTON, BIRMINGHAM, 24

Please send details of Schrader Air Pressure Regulators.

NAME.....

ADDRESS.....

21

WATER!

WATER!

WATER!

NOW

IS THE TIME TO PREPARE FOR NEXT SUMMER

HEENAN *Water Coolers*

ELIMINATE SHORTAGES, LOSS OF PRESSURE, RATIONING

1959 saw one of the greatest shortages of water that this country has ever experienced. It could happen in 1960—or any other year.

Do not risk your output being hampered or your business shut down, through reduction of town-water pressure, or actual cutting-off of supplies.

The Heenan Water Cooler uses the same cooling water over and over again. Be independent of the town's water supply—INSTALL NOW. Apart from all these advantages

THE HEENAN COOLER QUICKLY PAYS FOR ITSELF

H&F

HEENAN & FROUDE LTD., ENGINEERS, WORCESTER

FUEL EFFICIENCY—
the modern trend

FACTORIES & OFFICES

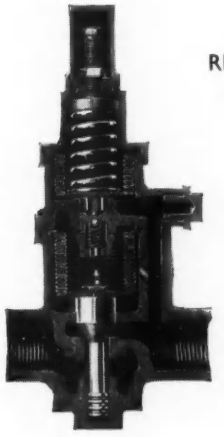
Whatever the size or type of building—whatever the nature of the business conducted within its walls, big fuel economies can be achieved by equipping your plant with

MIL

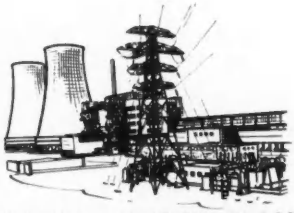
STEAM FITTINGS

SHIPS

HOSPITALS



MIL REDUCING VALVE



ATOMIC ENERGY PLANTS

SOME OF THE COMPANIES WE ARE PRIVILEGED TO SUPPLY:
Austin Motor Co. Ltd.
Bayliss, Jones & Bayliss Ltd.
Beans Industries Ltd. Bovril Ltd.
Carborundum Co. Ltd.
Fairey Aviation Co. Ltd.
Guest, Keen & Nettlefolds Ltd.
National Standard Co. Ltd.
Rolls-Royce Ltd.
Joseph Sankey & Sons Ltd.
Swallow Raincoats Ltd.
Vauxhall Motors Ltd.

MIL STEAM TRAPS

MIL WATER HEATER CONTROLS

MIL LOW PRESSURE STEAM TRAPS

MIL HIGH PRESSURE HOT WATER VALVES

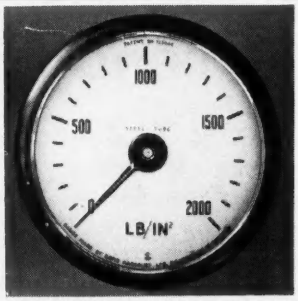
MIL AIR ELIMINATORS

MIDLAND INDUSTRIES LTD · HEATH TOWN WORKS · WOLVERHAMPTON

Telephone : 23901

London Office: 28 Victoria Street, S.W.1.

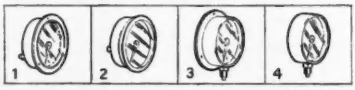
Glasgow Office: 69 St. Vincent Street, C.2.



THE DAVID HARCOURT EVEREST UNIT PRESSURE GAUGE

This patented unit is recommended for the more important installations. It is available with four mountings as illustrated below with 4" and 6" diameter dials.

Narrow flange, with rear clamp fixing, this model has a black, shock-resisting plastic case and is made with 4" and 6" dials, (large illustration) and (2).
Flush fitting, with back connection (1).
Surface connection, with bottom connection (3).
Direct mounting, with bottom connection (4).



David Harcourt Limited

LINKULA WORKS, COVENTRY ROAD, BIRMINGHAM, 10

A Member of SMITHS *Industrial Instrument Division*

BROADBENT & CO. (ROCHDALE) LTD.

Grove Spring Works, LINCOLN STREET, ROCHDALE, Lancs. *Phone: Rochdale 4628-9*

---

can you afford to stand still ?

. . . are you still losing time and money by repairing screw threads in the old-fashioned way?
Heli-Coil Screw Thread Repair Kits enable you to replace weak or stripped threads in minutes, at a cost almost too small to estimate!
Simply drill, tap and install a Heli-Coil Insert to produce a conventional thread many times stronger than an unprotected thread. It will outlast the rest of the part!
Although the cost of Heli-Coil Inserts is negligible, they are capable of making items serviceable when the metal is too worn to withstand ordinary screw thread repair. Years of use can now be obtained from parts that would otherwise have to be scrapped. The cost of complete replacements is saved and the inconvenience of delays. Three standard types of Heli-Coil Repair Kits are available, plus Special Purpose Kits " tailored " for particular products. Heli-Coil Inserts are made with either English, American or Metric Threads.

1909 GOLDEN JUBILEE 1959

HELI-COIL* screw thread repair kits

* *HELI-COIL is a registered trade mark*

MAIL THIS COUPON FOR FULL INFORMATION ABOUT HELI-COIL

PLEASE FORWARD ILLUSTRATED LITERATURE ON HELI-COIL SCREW THREAD REPAIR KITS TO:

NAME .....

COMPANY .....

ADDRESS.....

.....

ARMSTRONG PATENTS COMPANY LIMITED,
Eastgate Beverley, Yorkshire. *Tel:* Beverley 82212 (6 *lines*)

APL 48/K.9

Why waste Time? Thought? Effort? For that's what it means when you do your ordering in a piecemeal fashion. You can secure your requirements in Engineers' Small Tools, Macrome Treated Tools, Hand and Power Tools, all from one source, by the single logical decision—TOOLS FROM HALLMAC. It is but reasonable that you should control your buying in an organized manner by making use of Hallmac's vast and comprehensive stock ranges, available all over the country.

May we send you the latest Hallmac 44-page Stock List, now recognized as the foremost of its kind?

HALLMAC TOOLS LIMITED

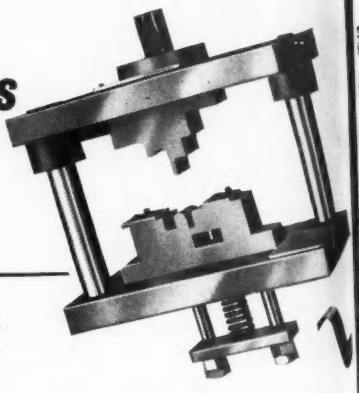
HEAD OFFICE AND DEPOT: *P.O. Box No. 39 Macrome Road, Wolverhampton. Telephone: 52001 (9 lines)*
LONDON: *Suite 418, Cayzer House, 2/4 St. Mary Axe, London, E.C.3. Telephone: AVEnue 5792*
MANCHESTER: *Transport House, 1 The Crescent, Salford, 5, Lancs. Telephone: Pendleton 3656*
GLASGOW: *Central Chambers, 11 Bothwell Street, C.2. Telephone: CENtral 5066*

Sales Managers for the Hand Tool Division of the Bron Manufacturing Company

JW. Ad 4457

SANDERSON tool steels

NEWHALL

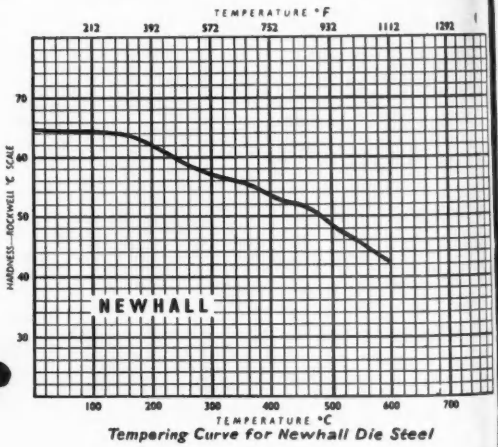


Characteristics
Oil hardening chromium tungsten type high grade alloy tool steel. Non-deforming; wide hardening range gives latitude in heat treatment —760°/790° C. light sections; 790°/820° C. heavy sections.

Applications
NEWHALL is suitable for numerous applications in which good wear-resistance and reliability in hardening are desired; broaches, bushes, machine parts, lathe centres, chuck jaws, master form tools, plug gauges, thread gauges and precision tools generally; cloth cutting knives, cold taps, reamers, collets, dies, drawing punches, cutting hobs, paper and metal slitting cutters are examples.

Forms available
Annealed for machinability, Newhall is supplied as black bar; as bright turned bar, or as precision ground flat stock.

PITHO brand NEWHALL Flat Stock saves costly machining or grinding operations. You select the correct size of flat stock, mark out and saw to the shape desired. Perfect surface; wide range of standard sizes from $\frac{3}{8}$" to 12" wide, 18" lengths, also in square sections and 24" lengths. Bars individually packed in envelopes. Write for details



Tempering Curve for Newhall Die Steel

SANDERSON'S

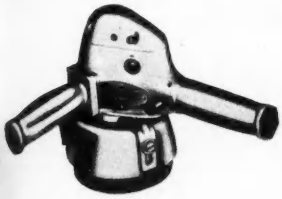
SANDERSON BROTHERS AND NEWBOULD LIMITED
Attercliffe Steelworks, P.O. Box 6, Newhall Road, Sheffield 9, England

ESTABLISHED 177

Ingersoll-Rand

air powered hand tools for industry

BRITISH MADE

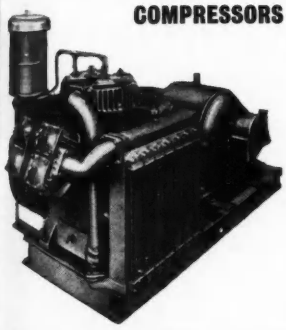


SURFACE GRINDERS

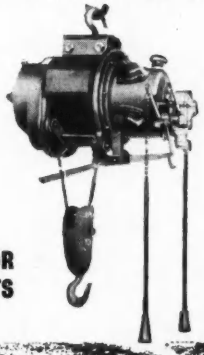
CHIPPING HAMMERS

GRINDERS

COMPRESSORS



SAND RAMMERS



MOTOR HOISTS

Power in hand with—

Ingersoll-Rand

INGERSOLL-RAND COMPANY LIMITED

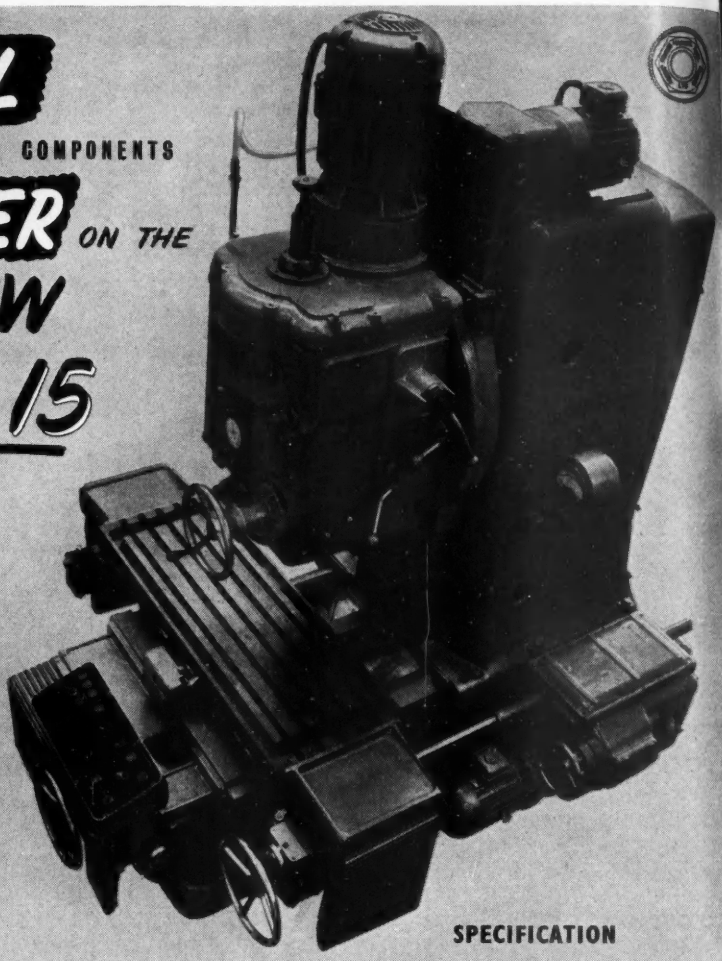
165 QUEEN VICTORIA STREET LONDON EC4 Tel: CEN 5681
SCOTTISH OFFICE: 20 RENFREW STREET GLASGOW C2
Tel: DOUGLAS 1233 Grams: INGERSOLL GLASGOW

P 3890

MILL

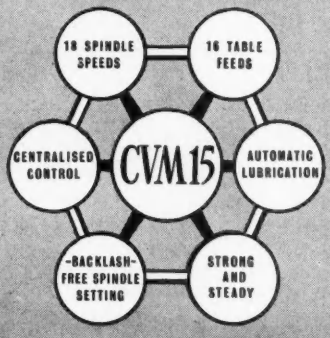
THOSE SMALLER COMPONENTS

FASTER ON THE NEW CVM 15



OPTIONAL EXTRAS

- SWIVEL MILLING HEAD
- POWER TRAVERSE TO SPINDLE
- BORING FEEDS TO SPINDLE
- RETRACTION OF SPINDLE
- INFINITELY VARIABLE FEEDS
- CYCLE MILLING
- TWO-DIMENSIONAL PROFILING
- AUXILIARY CIRCULAR TABLES
- SIDE MILLING MANDREL AND SUPPORT
- DIAL GAUGES FOR BORING



FOR FULL DETAILS WRITE TO

SPECIFICATION

WORKING SURFACE OF TABLE	54 in. x 16 in.
HEIGHT ADMITTED BETWEEN MIN.	1¼ in.
SPINDLE NOSE & TABLE MAX.	24 in.
DISTANCE FROM CENTRE OF SPINDLE TO FACE OF COLUMN	18 in.
SPINDLE ADJUSTMENT	6 in.
SPINDLE DRIVING MOTOR	10 h.p.
SPINDLE SPEEDS: up to 1600 r.p.m.	
THREE OPTIONAL RANGES OF 18 SPEEDS	
RANGE 1. 20 TO 1000 r.p.m.	
RANGE 2. 25 TO 1250 r.p.m.	
RANGE 3. 32 TO 1600 r.p.m.	
TABLE FEEDS: up to 63 ins./min.	
FOUR OPTIONAL RANGES OF 16 FEEDS	
RANGE 1. 0·8 TO 25 ins./min.	
RANGE 2. 1·18 TO 37·5 ins./min.	
RANGE 3. 1·6 TO 50 ins./min.	
RANGE 4. 2 TO 63 ins./min.	
TABLE RAPID TRAVERSE	100 ins./min.

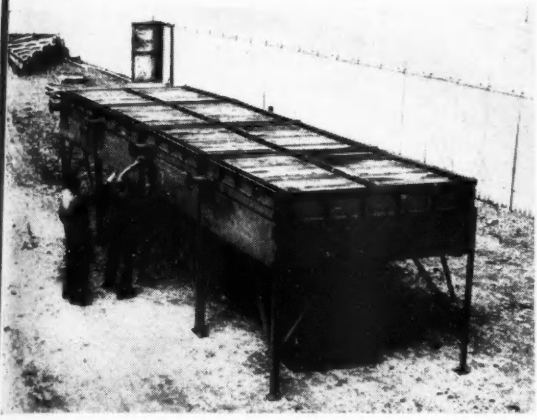
KENDALL & GENT

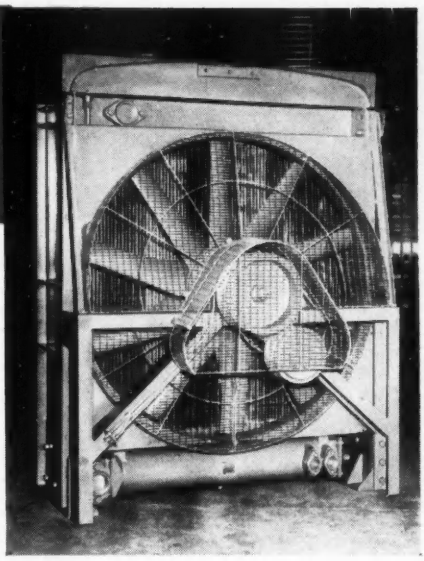
Phone EAST 1035 GORTON MANCHESTER

K249A

SERCK

HEAT EXCHANGE EQUIPMENT



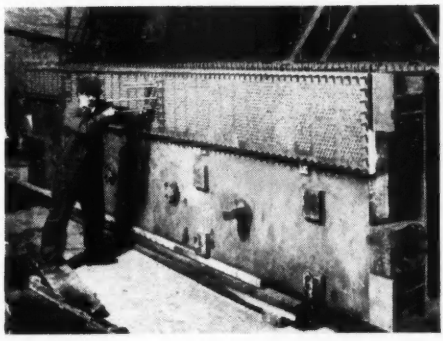


SERCK Combined Radiator and lubricating oil cooler for oil well drilling sets.

SERCK Horizontal type SECTIONAL RADIATOR.

and QUALITY TECHNICAL TUBES for THE OIL INDUSTRY

SERCKALBRA (Aluminium Brass)
SERCKCUNIK (Copper Nickel)
ADMIRALTY BRASS
ALUMINIUM BRONZE
70/30 BRASS



Evaporator for refinery by Procon (Great Britain) Ltd. being tubed with SERCKALBRA Photo by courtesy of Richardson, Westgarth & Co. Ltd.

SERCK RADIATORS LIMITED · SERCK TUBES LIMITED
Warwick Road Birmingham 11 England
MEMBERS OF THE SERCK GROUP

ST/2P

DESIGNERS! THIS IS THE ONE REFERENCE BOOK TO SOLVE YOUR FLUID SEALING PROBLEMS — AND IT'S FREE!

When you design Fluid Seal applications, don't be without this valuable Reference Book issued by Pioneer. Prepared by practical engineers, it includes the latest up-to-date information on Fluid Seal Technology, comprehensive data on a wide variety of applications, how to install correctly with easy-to-follow illustrations for all the various types of seals produced by Pioneer, and a full range of available sizes. The Pioneer Reference Book which comes to you on request, is a practical work for the busy designer and is part of the Pioneer service which includes free advice on any Fluid Sealing problem.

Pioneer

OILSEALING & MOULDING CO. LTD

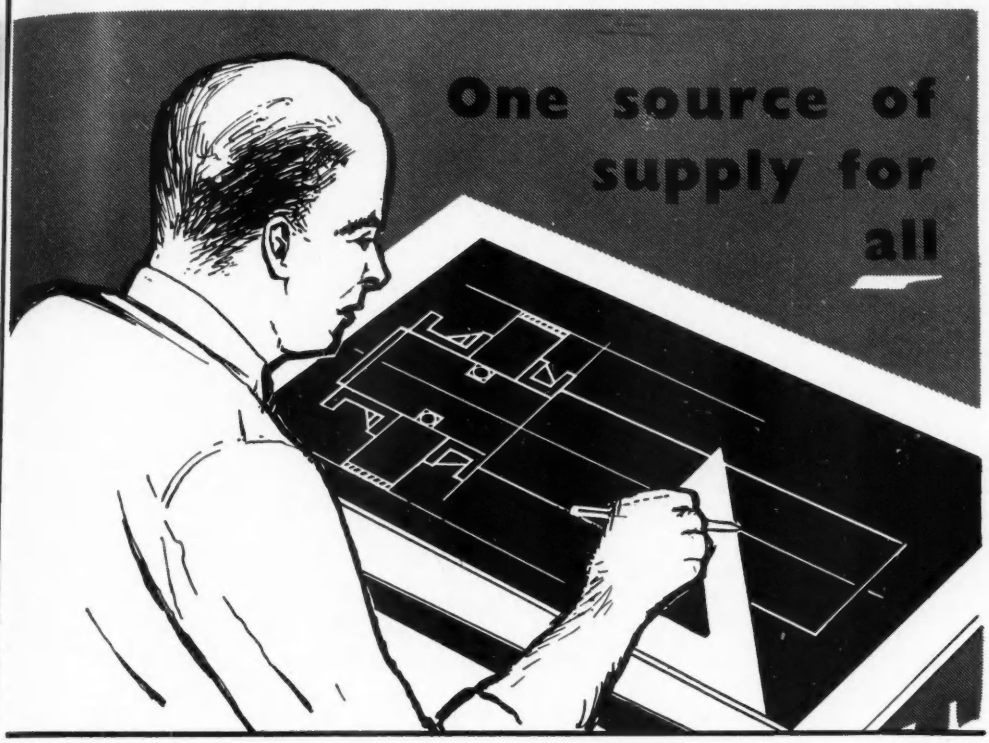
Factory and Head Office : Cottontree Works, Colne, Lancs. Tel: Wycoller 471 (8 lines)

GET YOUR COPY OF THE PIONEER FLUID SEAL CATALOGUE *NOW*

COMPANY NAME

ADDRESS

MARK FOR THE ATTENTION OF



..and ALL DESIGNED FOR THE JOB

It is difficult to illustrate, for example, how a cutting oil could be *designed* for the job . . . but designing (or formulating) of oils, on a thoroughly scientific basis, is precisely what we have been doing for over sixty years.

Whilst we have Cutting and Drawing Oils to meet every day-to-day requirement of the factory, and are always ready to advise on a suitable oil for a specific operation, we are also prepared, if necessary, to actually *design* (or formulate) an oil specially for the job, where that something " very special " is required.

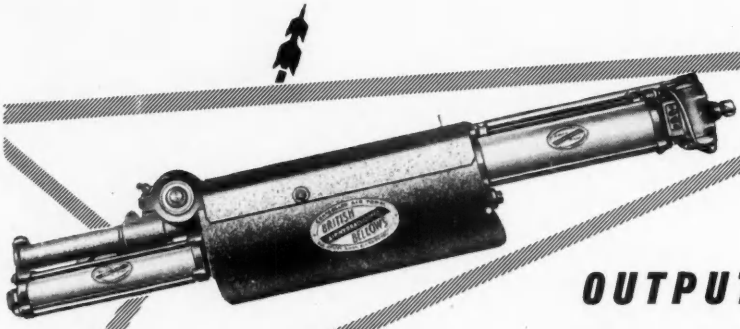
Please write for literature.

Other 'Edgar Vaughan' products include: Drawing Compounds, Hydraulic Oils and Fluids, Special Lubricating Oils and Greases, Fuel Oil additives, Rust Preventives, Heat Treatment Oils and Salts, Industrial Cleaners, Mechanical Leathers.

Edgar **Vaughan** *& Co. Ltd.*

BIRMINGHAM · 4 · ENGLAND

Works and depots at: Birmingham, Manchester, Liverpool, Southall (Middx.), Bristol, Glasgow.



OUTPUT ROCKETS!

when you install this

BRITISH BELLOWS DRILL FEED UNIT

One item in a comprehensive range, this drill feed unit is intended for the control of sensitive drilling machines, light milling, grinding and other advance/retract operations. It can be supplied with hand, foot or air control or (as illustrated) electrical control, each of which can be equipped with an Accurate Depth attachment. Deep Hole units are available in both Standard and Heavy Duty types.

Write for "Do It Yourself Automation", first step to higher output.

The second step—our engineers are always ready to advise on the selection and use of this equipment to give maximum results.

Manufactured and Distributed by: GEO. H. HUGHES LTD.

EDGEMOND AVENUE, TYBURN, BIRMINGHAM 24. • Tel.: ASHfield 1183

PRESSINGS

If you require pressings consult Ward (Metal Details) Ltd. We are specialists in the manufacture of all types of small and medium pressings of any shape, size and thickness, in steel, tinplate, copper etc. from which complete assemblies can be fabricated by welding, soldering or brazing.

Illustrated here are some examples of our products, and similar components can be produced to your own specification and design, and supplied in painted, plated or enamelled finishes.

WARD
(METAL DETAILS) LTD.

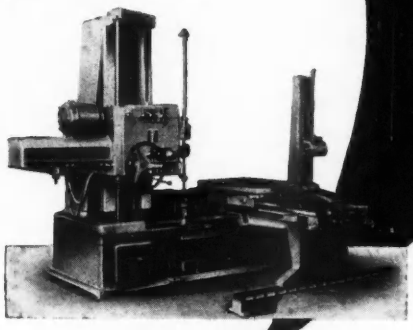
DARLASTON · STAFFS

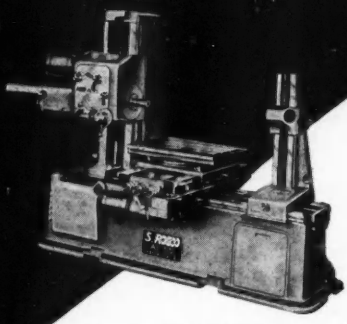
S. ROCCO

PRESENT THEIR RANGE OF HORIZONTAL BORING MACHINES

Horizontal Boring Machine Type AL 76

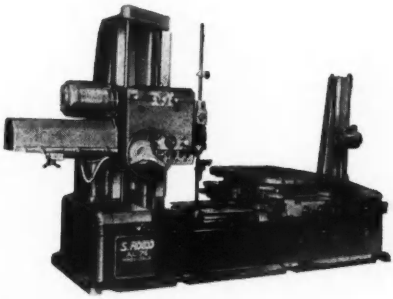
Spindle dia.	3"
18 Spindle speeds from	8.5 to 1500 rpm
Table dimensions	36" x 48"
Cross traverse	43" or 80"
Net weight	6.7 tons

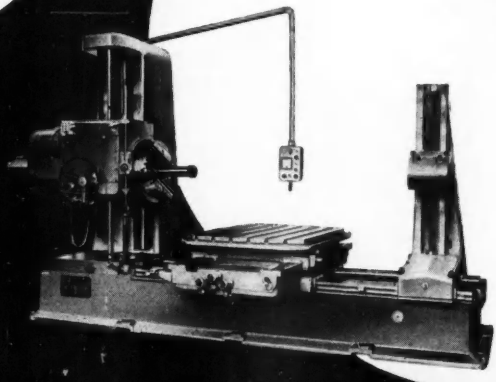




Horizontal Boring Machine Type AL 55

Spindle dia.	2" 1 8
18 Spindle speeds from	23 to 1380 rpm
Table dimensions	28" x 22"
Cross traverse	23" or 40"
Net weight	3.2 tons





Horizontal Boring Machine Type AL 92

Spindle dia.	3" 5 8
16 Spindle speeds from	7 to 1210 rpm
Table dimensions	40" x 50"
Cross traverse	58" or 80"
Net weight	12.5 tons.

INDIVIDUAL CATALOGUES ARE AVAILABLE IN WHICH OUR MACHINES ARE DESCRIBED IN DETAIL. PLEASE APPLY FOR CATALOGUES DIRECT TO:

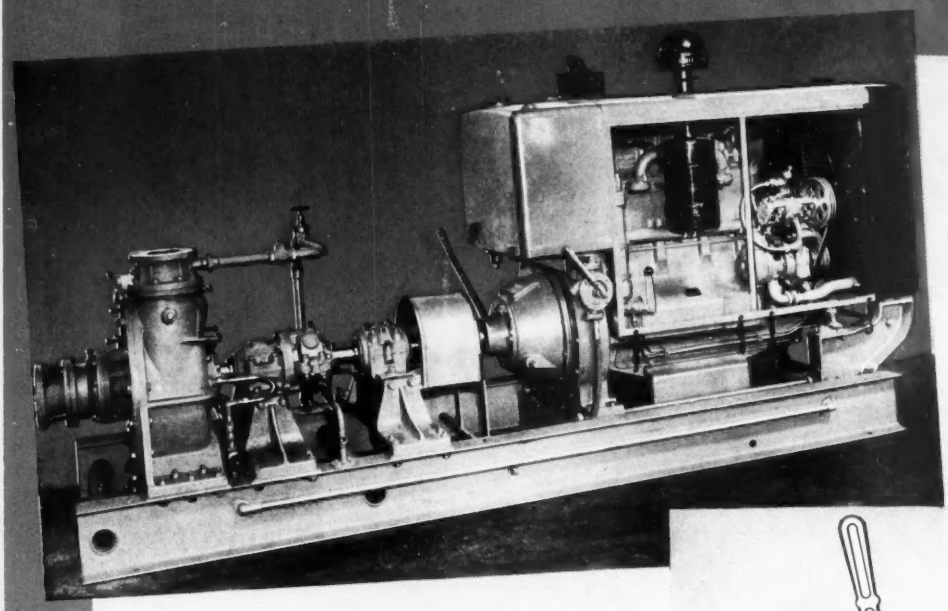
Sole Selling Agents U.K.

Newman

NEWMAN INDUSTRIES LIMITED

Machine Tool Division · Yate · Bristol

Telephone: Chipping Sodbury 3311



Heavy Duty Clutches

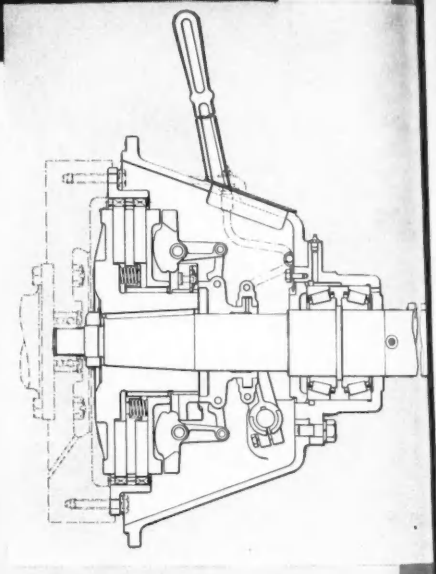
FOR INDUSTRIAL USE

Rockford power take-offs and clutches are of extremely rugged construction and due to their over-centre action they run, in either the engaged or disengaged position, entirely without running thrust—which is confined to the moment of operation only.

They are made in a wide range of sizes, and in single and twin-plate form.

The top illustration shows a 4½″ to 5″ sand and gravel pump, made by Easton & Johnson Ltd., Taunton, England.

The diesel engine drives the pump through a Rockford 14″ twin-plate clutch and power take-off (shown in the drawing).



Catalogues of Rockford and Borg & Beck clutches will be sent on request.

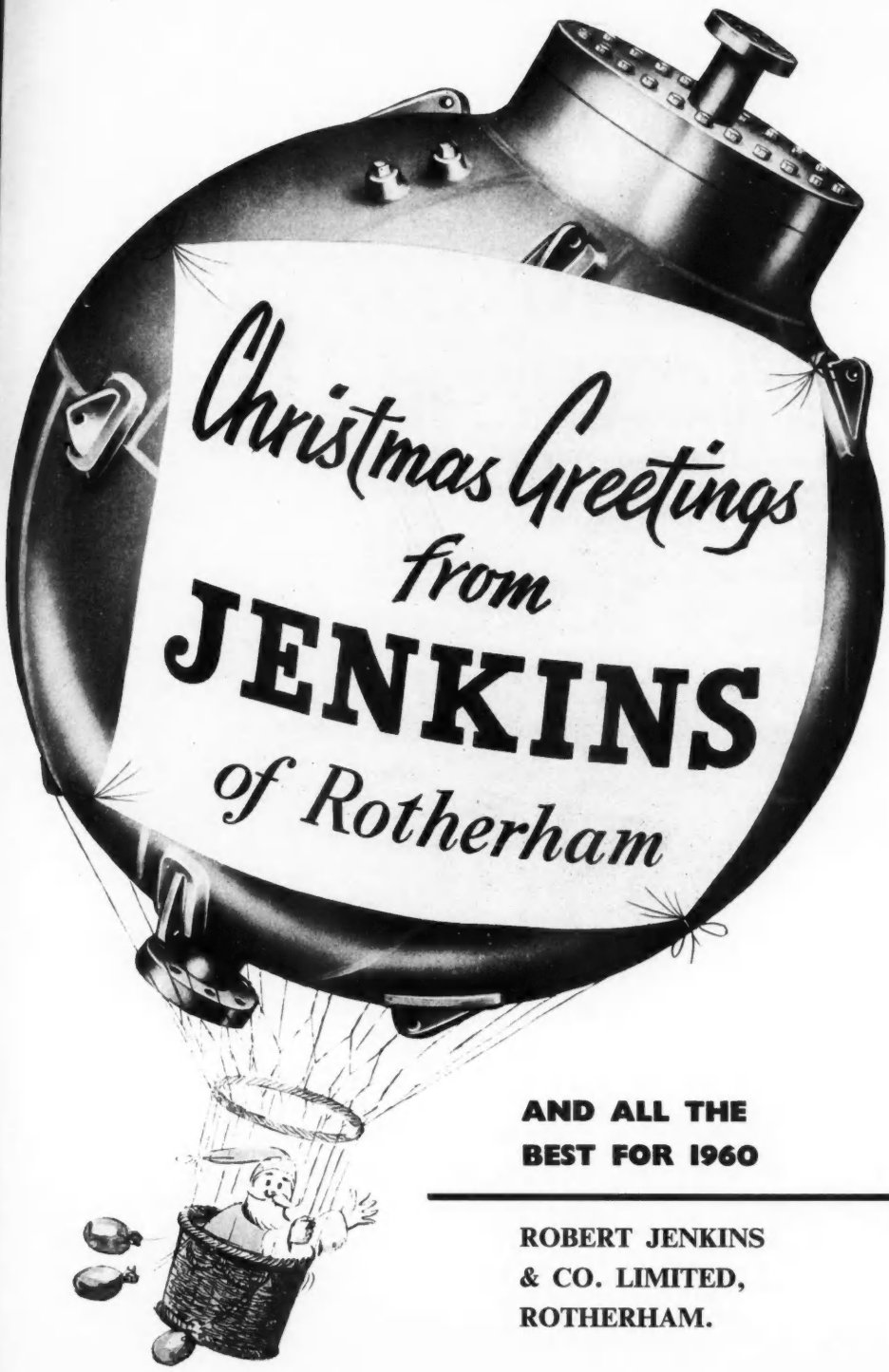
ROCKFORD

BORG & BECK COMPANY LTD

LEAMINGTON SPA, WARWICKSHIRE

ONE OF THE AUTOMOTIVE PRODUCTS GROUP

CLUTCHES AND POWER TAKE-OFFS



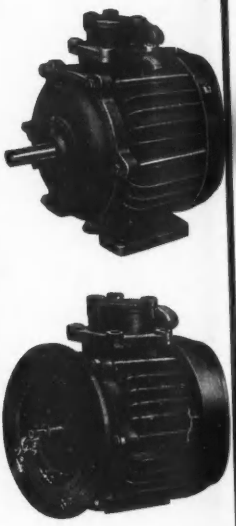
AND ALL THE BEST FOR 1960

ROBERT JENKINS & CO. LIMITED, ROTHERHAM.

STOP LOOKING

HERE IS THE ANSWER TO ALL YOUR D.C. AND FLAMEPROOF MOTOR PROBLEMS—

It's as simple as that. E.P.E. make an extensive range of D.C. and Flameproof Motors to suit almost every requirement. But E.P.E. service goes much further than that. With every post come orders and enquiries for motors to meet unusual requirements and standards with the certain confidence that if it's possible to produce such motors at all—E.P.E. design and manufacturing experience will find the answer.



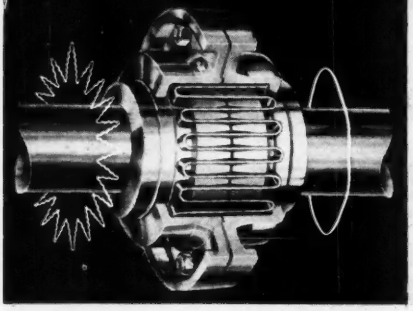
E·P·E

THE ELECTRICAL POWER ENGINEERING CO. (BIRMINGHAM) LIMITED.

Bromford Lane, Birmingham 8.
Telephone: STEchford 2261. 'Grams: Torque. 'Phone Birmingham.

London Office: 421 Grand Buildings, Trafalgar Square, London, W.C.2
Telephone: Whitehall 5643 and 7963

The most efficient couplings obtainable



BIBBY

Resilient

COUPLINGS

For nearly forty years Bibby Resilient Couplings have enjoyed an unexcelled reputation for efficiency and reliability and numerous Couplings supplied over thirty years ago are still giving trouble-free service.

The outstanding resilience of Bibby Couplings dampens shocks and vibrations, ensures smooth running of plant, eliminates breakdowns. Standard Couplings up to 7½" bore can be supplied from stock.

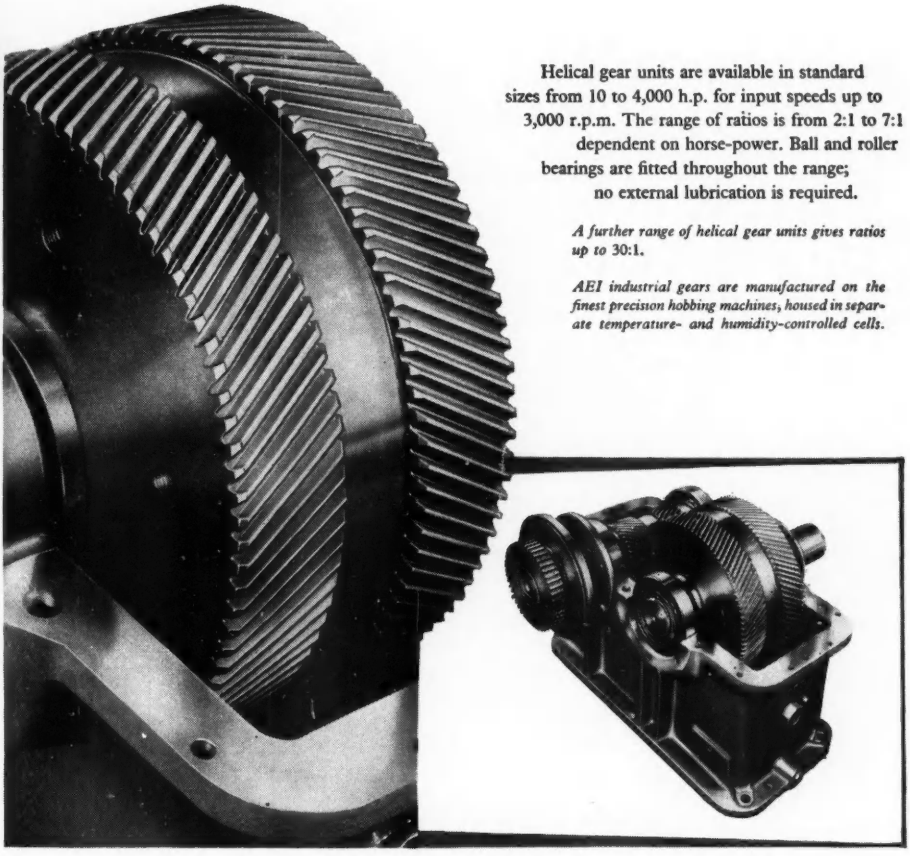
We invite you to write for our illustrated brochure.

THE WELLMAN BIBBY COMPANY LIMITED
PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1

Efficiency over 98%

with AEI

STANDARD INDUSTRIAL GEARBOXES



Helical gear units are available in standard sizes from 10 to 4,000 h.p. for input speeds up to 3,000 r.p.m. The range of ratios is from 2:1 to 7:1 dependent on horse-power. Ball and roller bearings are fitted throughout the range; no external lubrication is required.

A further range of helical gear units gives ratios up to 30:1.

AEI industrial gears are manufactured on the finest precision hobbing machines, housed in separate temperature- and humidity-controlled cells.

For further information and technical data please telephone Rugby 2121 ext. 108

ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

HEAVY PLANT DIVISION RUGBY & MANCHESTER, ENGLAND

A5300

Photographed by kind permission of Archers Garage, Birmingham.
"Contractor: R. Cook & Co. (Electrical) Ltd.,

Its easy to see—what a difference Thorlux "Adjustaflood" can make to visibility and attractiveness of car parks and forecourts.

LIGHT IN THE RIGHT PLACE—
AT THE RIGHT PRICE!!

Thorlux "Adjustafloods" may be clamped on to a pole, or fixed to a wall, and adjusted to the required angle to allow maximum light over the required area. The standard size is 27 in. x 24 in. with the reflector finished in vitreous enamel green and white with a die-cast aluminium top. Recently the design of Thorlux "Adjustafloods" has been improved still further and more efficient production enables them to be offered at a NEW LOW PRICE.
Suitable for 200/1500 watt gas filled lamps:
250/400 watt discharge lamps.

WHAT A DIFFERENCE

THORLUX REGD. *THROWS LIGHT ON INDUSTRY*

CAN MAKE

INDUSTRIAL LIGHTING EQUIPMENT

F. W. THORPE LIMITED, Welby Road, Hall Green, Birmingham, 28. Tel. Springfield 3318-19-20. Grams. Thorlux, Birmingham

---

CLASS P CAT. 440 AC5 **ENERGY LIMITING**
REWIREABLE FUSE LINKS

Aeroflex

Offer Advanced Characteristics

This range of Aeroflex Fuses has a proved breaking capacity of 46 KA and a standardised fusing factor of 1.25. Known as the AD and FC types, they are fully interchangeable with their predecessors, the AF and CM patterns, and, of course, they are rewireable—fuse links are not discarded when blown, they can be returned for prompt replacement in our rewiring service scheme. *Send for Publication CF.2.*

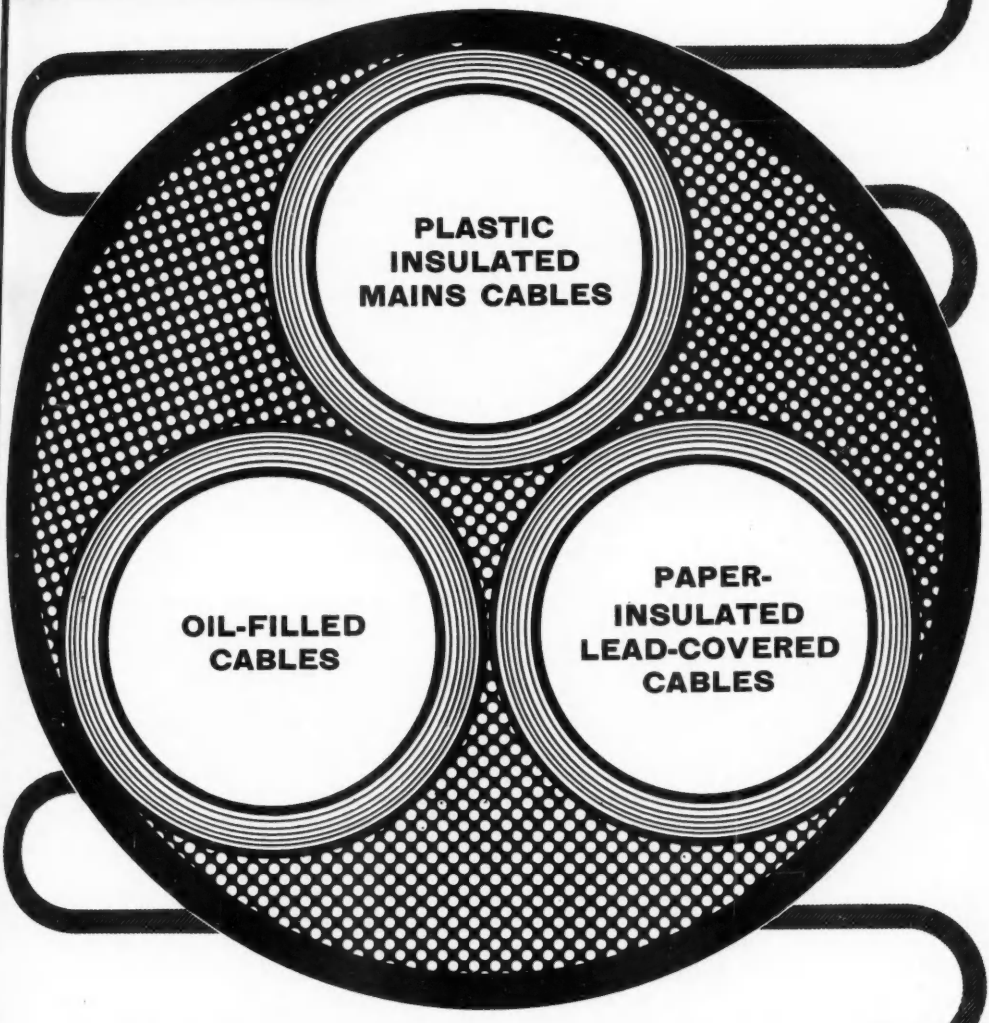
Parmiter Hope & Sugden Ltd

MANCHESTER 12.

London: 34, *Victoria St., S.W.1.* *Glasgow:* 5, *Somerset Place, C.3.* *Birmingham:* 39/41, *Carrs Lane,* 4.

dm PH132

Standard



CABLE
AND WIRE
GROUP

Standard Telephones and Cables Limited

Registered Office: Connaught House, 63 Aldwych, London, W.C.2.

POWER LINE DIVISION · NORTH WOOLWICH · LONDON · E.16

Telephone: Albert Dock 1401

TUBE EXPANDERS FOR ALL PURPOSES

The Wicksteed Automatic Torque Control Unit. Designed for use with a conventional drill type electric Motor accurately produces uniformly pressure tight tube joints. When the present torque limit is reached the motor automatically reverses. Standard Units are for 100/120 or 210/240 volts A.C., with voltage variation compensation. Using Wicksteed adjustable ball bearing thrust type Expanders, tubes ½" to 1" and under certain conditions smaller and larger tubes, can be accommodated Write for further details.

As supplied to the ADMIRALTY, BRITISH ELECTRICITY AUTHORITY, RAILWAYS, OIL REFINERIES, LEADING BOILER MAKERS and INDUSTRIAL USERS.

Leading Tube Expander Manufacturers for Over 70 Years

Charles Wicksteed & Co. Ltd. Kettering, England Tel: Kettering 3113

WICKSTEED

REGISTERED TRADE MARK

HERMETIC RUBBER PRODUCTIONS

To meet every need of Modern Industry in current production or future development.

Our many years of experience as manufacturers in Natural or Synthetic Rubber are at your disposal.

Moulded Products of all kinds, Flexible Fabric Coupling Discs, Extruded Rubber Sections, Radiator Hose (Canvas Inserted), Mud and Stone Deflectors, Mats and Matting.

Est: 1895

HERMETIC RUBBER CO. LTD.

RYLAND STREET. BIRMINGHAM, 16

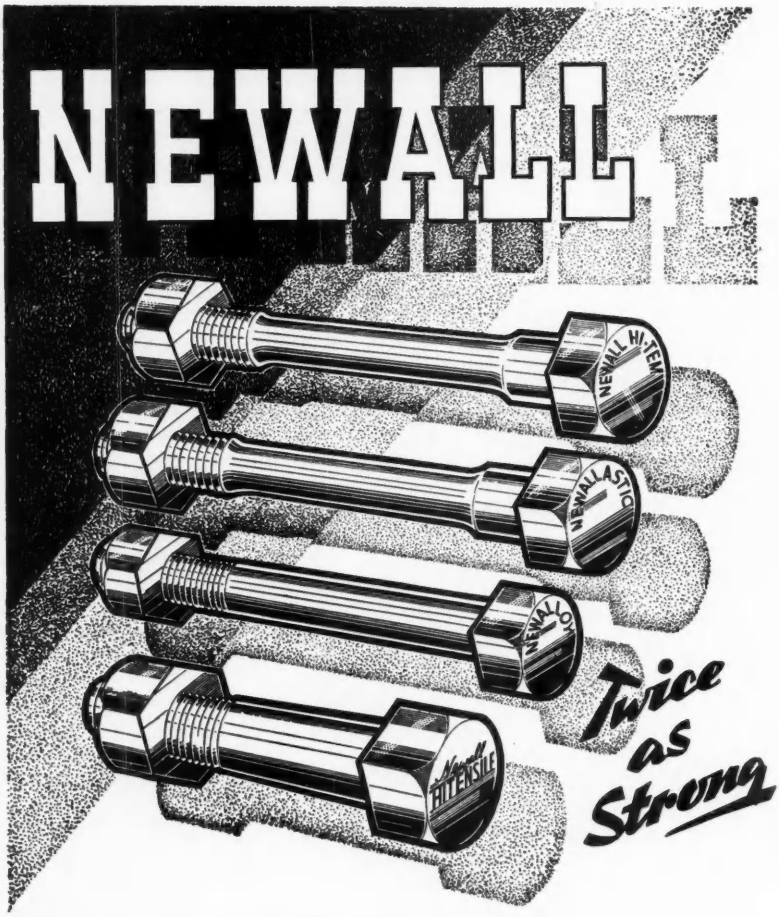
Telephone: Edgbaston 0983/4
Grams: Hermetic Birmingham

service in all shapes & sizes!

for Superior Dropforgings

THE BLACKHEATH STAMPING CO. LTD.

BLACKHEATH BIRMINGHAM · *Telephone: Blackheath 1448/9*



NEWALL BRANDED BOLTS

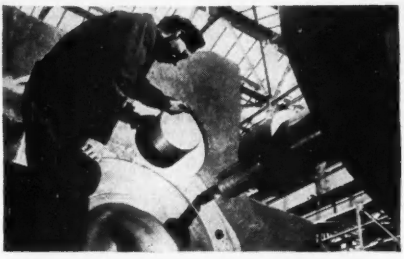
Newall Hitensile . . . Newalloy . . . Newallastic . . . Newall Hi-tem

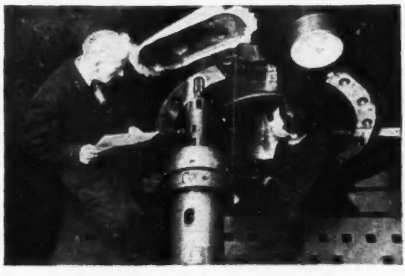
are recognised by engineers as having unique qualities. We shall be happy to supply any engineer designer who is interested with details of the various bolts and studs, which cover the full range of modern requirements.

A.P. NEWALL & CO., LTD. POSSILPARK GLASGOW N2

DRILL and TAP with *EaSiCut*

Whether you are machining parts of this size, or the smallest, leave no room for error. Specify Easicut, the tools you can depend on for consistent performance.





Drilling and Tapping a cast steel Main Crosshead, weight approximately 114 tons, using Easicut drills $2^{1}/_{16}''$ diameter and Easicut taps $2\frac{1}{4}''$ B.S.F.

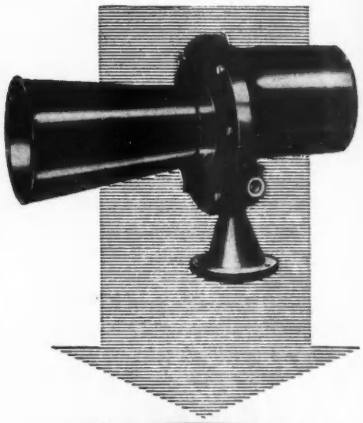
ENGLISH STEEL

TOOL CORPORATION LTD

North Street Works, Openshaw, Manchester

Stocks also held at: 167 Dukes Road Acton, London, W.3; 62-64 Scotswood Road, Newcastle; 2181 Coventry Road, Sheldon, Birmingham, 26; Holme Lane Works, Sheffield.

THE BIG NOISE
IN SIRENS, HOOTERS AND HORNS



KLAXON, the first name in Sirens, Horns and Hooters, offers a wide range of types for all industrial and marine warning, signalling and alarm purposes. Available in motor-driven or hand-operated models, these horns send out a clear, distinctive note of far-reaching power and intensity. The horn illustrated above, for instance, has a unique sound range of one mile in still air and is a typical example of Klaxon efficiency. Klaxon are also makers of all kinds of fractional motors and geared units up to 1 h.p.

Full range of models specially designed for use in

MINES AND OTHER SITUATIONS REQUIRING BUXTON CERTIFIED FLAMEPROOF SIGNALS · DOCKS · FACTORIES WAREHOUSES · SHIPS · YACHTS · CARS, etc.

KLAXON – *The Sound Investment*

KLAXON

Details of full range on request:

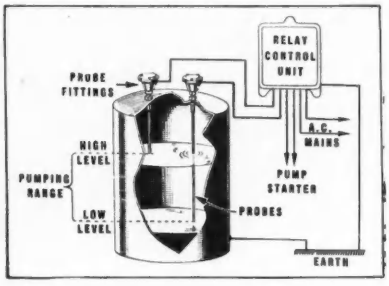
KLAXON LTD., WARWICK RD., TYSELEY, BIRMINGHAM 11. Tel: Acocks Green 1654-6. Also at TINGEWICK RD., BUCKINGH

LONDON SALES OFFICE: 76 JERMYN STREET, ST. JAMES'S, S.W.1. WHitehall 0411 (PBX) *One of the Windsor Group of Compa*

---

level controls

high/low pump switching or level signalling at low cost



A typical level control application

THE well tried Elcontrol system uses a single relay unit and two sturdy probes, installation is easy and there is nothing to go wrong.
Conductivity type for all liquids except insulants.
Widely used for foam level control, oil/water interface detection; works very well on condensate. Probe system operates at very low voltage. Flame-proof and intrinsically safe versions can now be supplied.

Appointed Agents	*Telephone*
MIDLANDS: A. M. Lock & Co. Ltd., Newborough Rd., Solihull.	*Shirley 5703*
N. WEST: A. M. Lock & Co. Ltd., Union St., Oldham.	*Main 6744*
SCOTLAND: A. R. Bolton & Co., 3a St. Vincent St., Edinburgh 3.	*32035*

ELCONTROL

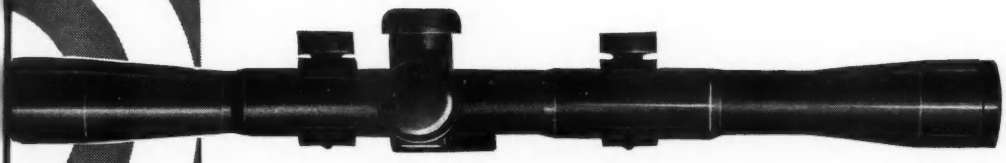
Regd. Trade Mark

write to **ELCONTROL LTD., HITCHIN, HERTS.** *Hitchin 2411*

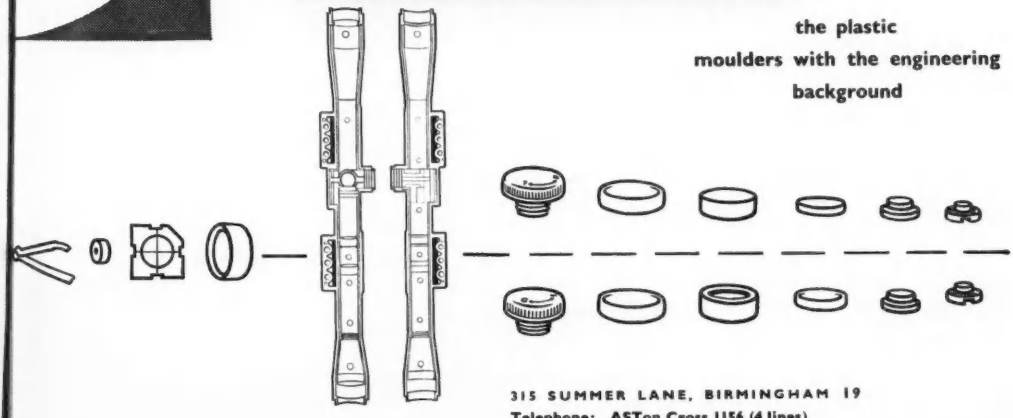
This plastic gunsight is a precision optical instrument with an optically ground glass lens system designed and produced by our associate company British Optical Lens Co., and giving 2x or 4x magnification. Light in weight it incorporates a fine adjusting ratchet device of extreme accuracy for the control of both vertical and horizontal graticules for which a 0.0003 in. nylon filament in the form of a + is used.

we kept our sights on the target

Sixteen separate injection mouldings and a 4-piece lenses system are incorporated in the 2x gunsight. A 5-piece lenses system for the 4x gunsight. We designed and made the tools and, of course, produced the mouldings. Finally, the whole job is completely assembled in our factory. The gunsight is produced by us for the world-famous B.S.A. company.



E. Elliott Limited



the plastic moulders with the engineering background

315 SUMMER LANE, BIRMINGHAM 19
Telephone: ASTon Cross 1156 (4 lines)

Could this be the spring you're looking for?

Then you'll find it down below

Whatever you need in the way of springs you'll find in the range of TERRY'S BOXES OF ASSORTED SPRINGS—compression, expansion, long, short, light, heavy—the lot.

Just the job for you experimental people—a simply unlimited assortment from our tremendous range of springs of every variety. The boxes shown here are only a few examples—why not let us send you our illustrated list showing them *all?*

No. 760. 3 doz. Assorted Light Compression Springs. 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. 6/6 each.

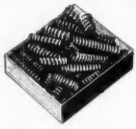
No. 388. ½ gross Assorted Small Expansion Springs. ¾" to 1½" long, ¼" to ½" diam., 18G to 21G. 9/6 each.

No. 757. Extra Light Compression, 1 gross Assorted, ¼" to 7/16" diam., ½" to 2½" long, 27 to 19 S.W.G. 15/- each.

No. 466. ½ gross Assorted Small Expansion Springs ¾" to 1½" long, 3/32" to 3/16" diam., 21G to 24G. 6/6 each.

No. 758. Fine Expansion Springs. 1 gross Assorted ¼" to ⅝" diam., ½" to 2" long, 27 to 20 S.W.G. 15/- each.

No. 753. 3 doz. Assorted Light Expansion ¼" to ½" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6 each.

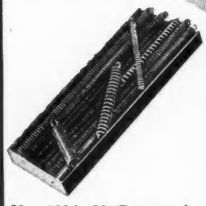


No. 98A. 3 doz. Assorted 1" to 4" long, ½" to ⅝" diam., 19G to 15G. 5/6 each.

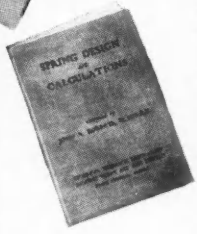
Cut production costs with Terry Wire CIRCLIPS

(Square Section)

We can supply from stock in sizes from ⅛" to ⅝".



No. 1024. 20 Compression Springs 12" long. ⅛" to ½" diam., 24G to 18G, suitable for cutting into shorter lengths; and 30 Expansion 1½" to 12" long. 5/32" to ⅝" diam., 22G to 16G. 24/- each.



*Interested in Springs? Ninth Edition of "Spring Design & Calculations" — post free 12/6.

TERRY'S

ASSORTED SPRINGS

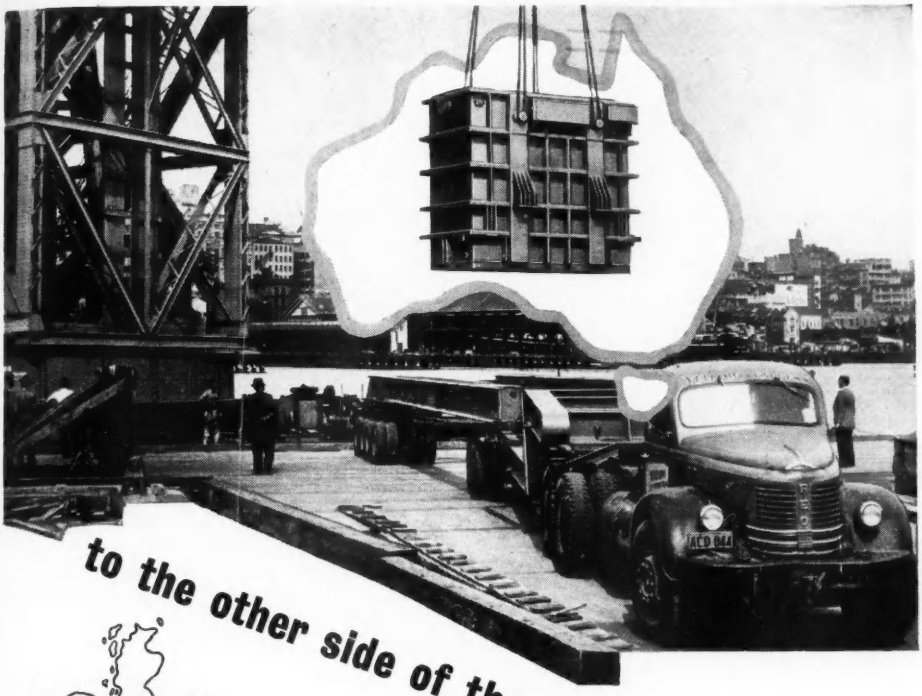
Herbert Terry & Sons Ltd., Redditch, Worcs.

(Makers of Quality Springs, Wireforms and Presswork for over 100 years)

*** Have you a Presswork problem?**

If so let us have it and we'll help to solve it for you.

HT 26 B



to the other side of the world...

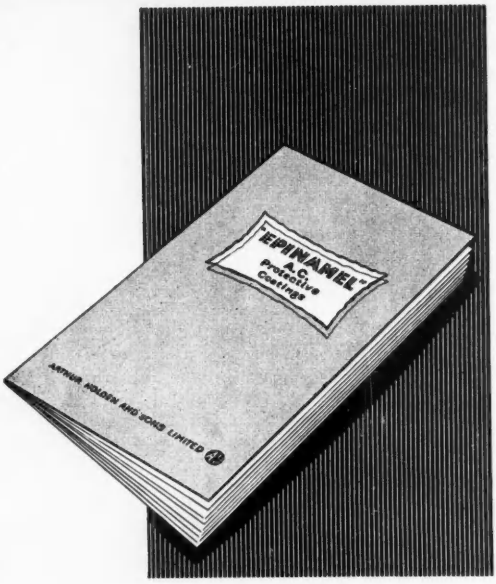
HACKBRIDGE TRANSFORMERS

Many large Hackbridge transformers have been installed in Australia, including units up to 100 MVA 220/110 kV.

The illustration shows a Hackbridge 45-MVA 129/33/10.85 kV equipment being loaded on to a transport vehicle at Sydney Docks.

HACKBRIDGE & HEWITTIC ELECTRIC CO., LIMITED
WALTON-ON-THAMES, SURREY, ENGLAND
Telephone: Walton-on-Thames 28833 (8 lines) *Telegrams & Cables: "Electric, Walton-on-Thames"*

OVERSEAS REPRESENTATIVES. ARGENTINA : H. A. Roberts & Cia., S.R.L., Buenos Aires. AUSTRALIA : Hackbridge and Hewittic Electric Co. Ltd., 171, Fitzroy Street, St. Kilda, Victoria ; N.S.W. : Queensland : W. Australia : Elder, Smith & Co. Ltd. ; South Australia : Parsons & Robertson Ltd. ; Tasmania : H. M. Bamford & Sons (Pty.) Ltd., Hobart. BELGIUM & LUXEMBOURG : Pierre Pollie, Brussels 3. BRAZIL : Oscar G. Mors, Sao Paulo. BURMA : Neonlite Manufacturing & Trading Co. Ltd., Rangoon. CANADA : Hackbridge and Hewittic Electric Co. of Canada Ltd., Montreal ; The Northern Electric Co. Ltd., Montreal, etc. CEYLON : Envee Ess Ltd., Colombo. CHILE : Sociedad Importadora del Pacifico Ltda., Santiago. EAST AFRICA : G. A. Neumann., Nairobi. EGYPT : Giacomo Cohenca Fils, S.A.E., Cairo. FINLAND : Sähkö-ja Koneliike O.Y. Hermes, Helsinki. GHANA, NIGERIA & SIERRA LEONE: Glyndova Ltd. GREECE: Charilaos C. Coroneos, Athens. INDIA : Steam & Mining Equipment (India) Private Ltd., Calcutta ; Easun Engineering Co. Ltd., Madras 1. IRAQ : J. P. Bahoshy Bros., Baghdad. MALAYA, SINGAPORE & BORNEO : Harper, Gilfillan & Co. Ltd., Kuala Lumpur. NETHERLANDS : J. Kater E. I., Ouderkerk a.d. Amstel. NEW ZEALAND : Richardson, McCabe & Co. Ltd., Wellington, etc. PAKISTAN : The Karachi Radio Co., Karachi 3. SOUTH AFRICA : Arthur Trevor Williams (Pty.) Ltd., Johannesburg, etc. CENTRAL AFRICAN FEDERATION : Arthur Trevor Williams (Pty.) Ltd., Salisbury. THAILAND : Vichien Phanich Co. Ltd., Bangkok. TRINIDAD & TOBAGO : Thomas Peake & Co., Port of Spain. TURKEY : Dr. H. Salim Öker, Ankara. U.S.A. : Hackbridge and Hewittic Electric Co. Ltd., P.O. Box 234, Pittsburgh. 30, Pennsylvania. VENEZUELA : Oficina de Ingenieria Sociedad Anonima, Caracas.



"EPINAMEL"
ANTI-CORROSION COATINGS

The solution to your corrosion problems

SEND FOR THIS BOOKLET

Everything you need to know about the amazing new "Epinamel" A.C. Protective Coatings is here.
This publication explains why "Epinamel" has revolutionised methods of protecting metalwork from all kinds of corrosive influences.
It is not just a brochure, but a reference work of lasting usefulness and interest.
How many copies would you like?

ARTHUR HOLDEN & SONS LTD.

Bordesley Green Rd., Birmingham, 9. Tel. Vic. 27

Have you a heat treatment problem?

Made in a wide range of standard sizes or built to customers specifications, AEW Electric Ovens and Furnaces embody the most advanced features for all Industrial Heat treatment processes.

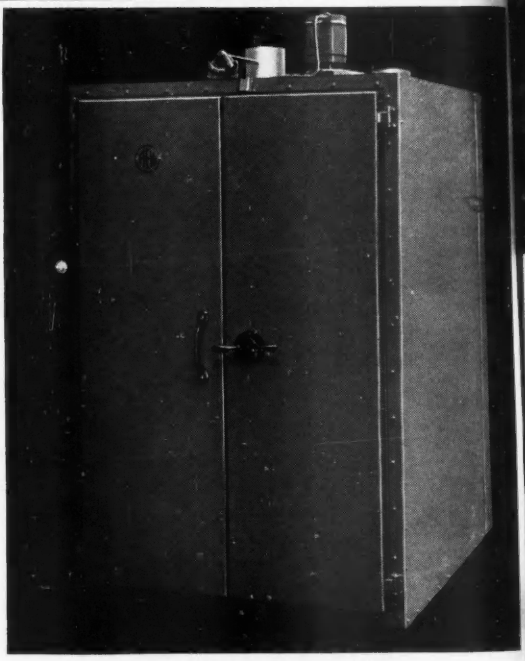
Standard ovens built for temperature up to 400°C.

High temperature ovens suitable for temperatures up to 750°C.

Our Technical Advisory Service is freely available for solving your heating problems.

Please write for fully informative brochure.

A. E. W. Ltd.
Imperial Works, Edgware, Middx.
Telephone: Edgware 5278



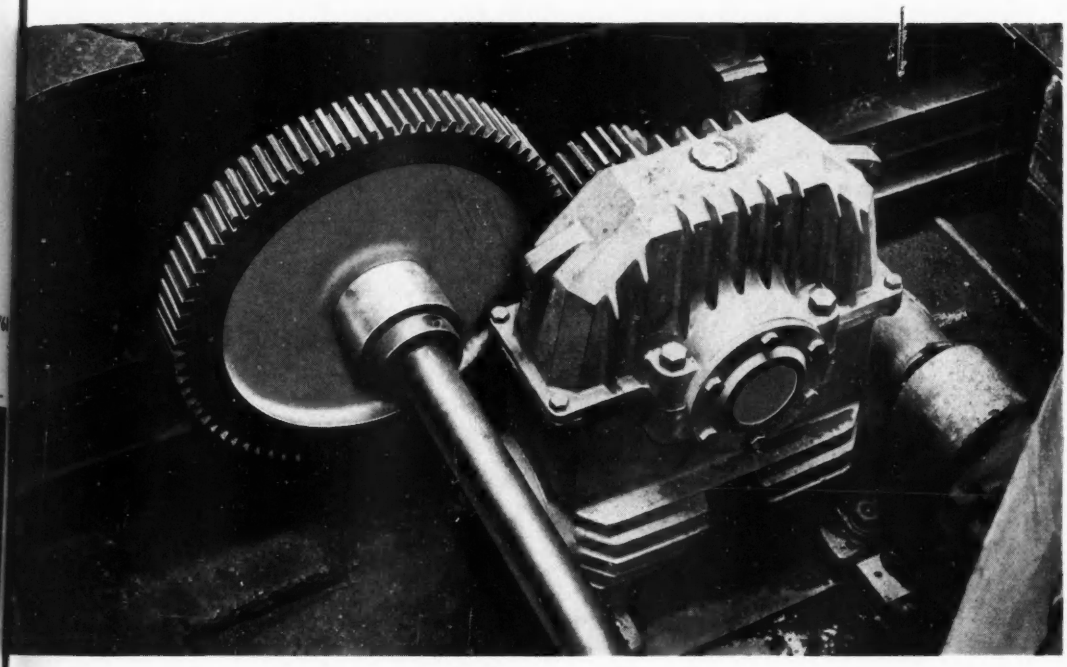
Type 1077 Standard Industrial Oven.

Gear life trebled with Harper S. G. Castings!

These drive wheels for a high-duty conveyor were originally made in cast steel. Wear was very severe and replacements difficult to obtain.

The Chief Engineer says :-
"By changing to Harper S.G. iron the life has been increased up to three times and at the same time the cost of a set of gears has been considerably reduced."

Have you a case where steel forgings, castings or fabrications could be replaced by Harper Castings, with considerable savings and better service ? Let us look at your problem to see if Harper foundry technique can help you—it probably can !



Harper quality covers Grey Iron, Spheroidal Graphite Iron (Mond Nickel Licence) and Meehanite castings. Metal pressings, machining, enamelling and sub-assembly work.

The word MEEHANITE is a registered trade mark.

Also makers of the famous Beatrice Oil Heaters and Harper Housewares.

Please write for our chart, which gives technical information on our mixers.

HARPER CASTINGS

JOHN HARPER & CO. LTD. WILLENHALL STAFFS

Phone: WILLENHALL 124 (5 lines) · LONDON, Phone: ABBey 5906/7 · MANCHESTER, Phone: BLAckfriars 0295

FOUNDED · 1790

CASTINGS WITH THE HARPER SKIN

H661

There's talk of Sykes in the High Street

The rows of shining kitchen equipment which housewives in their thousands see in the big stores would have seemed a fantasy two generations ago. They have made life in countless homes immeasurably more pleasant. And although not many housewives know it, Sykes have done a great deal to make such comforts possible. Consider, for example, washing and ironing machines, food grinders and mixers, automatic oven timing devices. In the development of each of these Sykes have played a prominent part.

For instance, some time ago, they were consulted by an inventor of kitchen machinery who had a first-class idea but required more detailed technical knowledge about the gearing involved.

Sykes advised on the type of gearing most suitable, suggested certain production methods, and then made recommendations for the most efficient type of machine to suit the labour available. As a result, this invention is now used in homes all over the country, and its name is a household word.

The truth is that there are not many production engineers in a position to solve intricate problems connected with transmissions and gearing. So, naturally, many people looking for help and advice in this field come to Sykes. They know that Sykes have been producing first-class gear generating equipment for a long time, and therefore have a rich fund of experience to draw from. That is why their Technical Sales Advisory Service—which makes their expert knowledge available to everyone who asks for it—has become a vital part of their business.

Talk to SYKES about gear production

W. E. SYKES LIMITED · STAINES · MIDDLESEX · ENGLAND and associated companies : Sykes Tool Corporation Ltd., Georgetown, Ontario, Canada
Sykes Machine & Gear Corporation, Newark, NJ, USA
W. E. Sykes Ltd., Mascot, Sydney, NSW, Australia

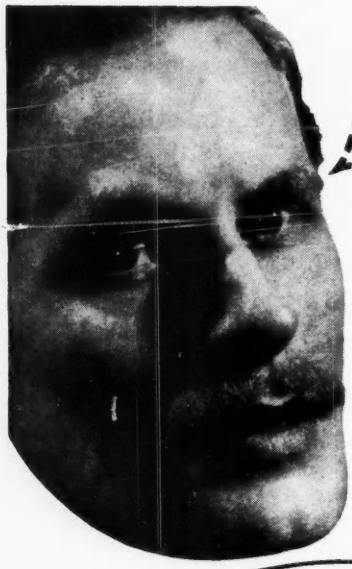
Brobdingnagian or Lilliputian?

It is improbable that Dean Swift had any thoughts about ball bearings in his curious romancings, but he would, we believe, appreciate the well-balanced design and fine finish of both our big and little fellows. We have made bearings as large as 5′ 0″ diameter to support a locomotive turntable whilst their tiny counterparts, some as small as 3mm, diameter, may be used on a very high speed dental drill, or perhaps for an instrument where the need is not for speed but extremely sensitive motion. These Lilliputians of engineering are held to B.S.I. limits of accuracy or to the American specifications ABEC 3, 5 or 7.

HOFFMANN

PRECISION MINIATURE
BALL BEARINGS

THE HOFFMANN MANUFACTURING CO. LTD., CHELMSFORD, ESSEX



These initials guarantee the quality

"CRS" stands for Charles Richards & Sons, of course. The extra 'R' stands for the grade, and identifies the bolt as a 'Hi-Strain' 45/55 tons tensile. And all of it means high resistance to stress and vibration. See that *your* bolts are signed with this long-lasting guarantee of maximum safety

RICHARDS

hi-strain BOLTS

CHARLES RICHARDS & SONS LTD.
P.O. BOX No. 23 - DARLASTON - WEDNESBURY - SOUTH STAFFS.
'Phone: James Bridge 3188 (8 lines) P.B.X. Wires: "Richards" Darlaston

---

multi-spindle drilling attachments

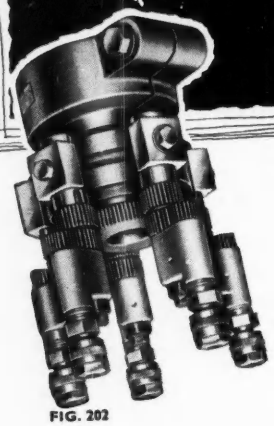


FIG. 202

multi-spindle tapping attachments

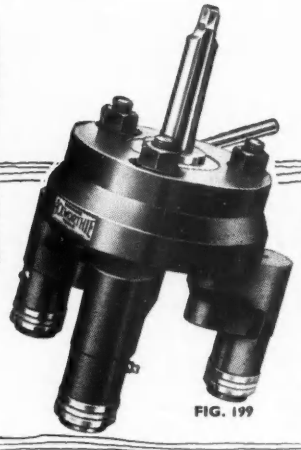


FIG. 199

Multi Spindle Drilling—Multi Spindle Tapping. 2 Spindles to 20—fully adjustable or fixed. Send today for your copy of "Automation by Ackworthie/C"

Illustrated Ackworthie Multi Spindle Drilling attachments Fig. 202 and Fig. 199 designed to give a wide range of Spindle adjustment. Special Machines built to customers' requirements.

ACKWORTHIE

JOHN ACKWORTHIE LTD
Dalehouse Lane, Kenilworth, Warwickshire
Telephone: Kenilworth 1530 (P.B.X.)

SUSTAINED ACCURACY

with carbon vanes

Photograph by courtesy of Shell and BP Ltd.

The refuelling of B.O.A.C.'s Britannia is a routine job for the 4,000 gallon "fuellers" of Shell and BP Aviation Services, and one which demands reliable and accurate equipment. The supply is metered by Avery-Hardoll Bulkmeters, using MORGANITE CARBON VANES.

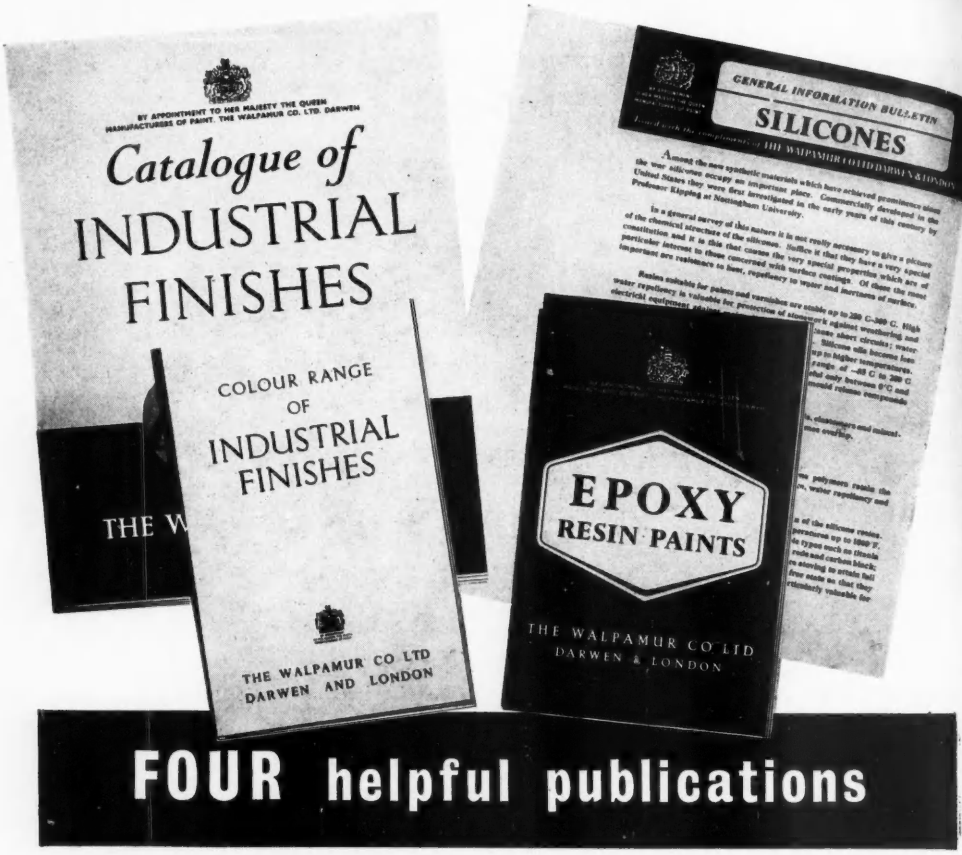
Impervious to chemical action, strong and highly resistant to wear, MORGANITE CARBON VANES have proved their reliability in action; after many millions of gallons, the accuracy of metering has not varied at all! MORGANITE CARBON VANES solved the problem for Avery-Hardoll Ltd.,—perhaps they will solve yours. Please write or telephone for leaflet SD 69, or for one of our Technical Advisers to call.

MORGANITE CARBON VANES resist chemical atmospheres and corrosive conditions; withstand high temperatures, immersion in liquids; are non-contaminating; need no lubricating; are suitable for inaccessible positions and completely eliminate maintenance.

MORGANITE VANES

C69a

THE MORGAN CRUCIBLE COMPANY LIMITED,
BATTERSEA CHURCH ROAD, LONDON, S.W.11. **Telephone: BATtersea 8822**



Constant research has ensured that Walpamur Industrial Finishes meet every requirement of modern industry, and these four free publications will help you to make the best possible use of this extensive range.

CATALOGUE OF INDUSTRIAL FINISHES describes the pre-treatment of metal surfaces before painting and gives details of primers, fillers and stoppers, stoving finishes,enamels, nitro cellulose finishes etc.

EPOXY RESIN PAINTS booklet details the complete range of FEROX epoxide resin based paints, including stoving, air drying, and cold cure finishes for many industrial requirements.

SILICONE LEAFLET gives information about the use of silicone in heat resisting and water repellant paints, bonding varnishes, etc.

INDUSTRIAL SHADE CARD shows the complete range of colours available for all types of finishes.

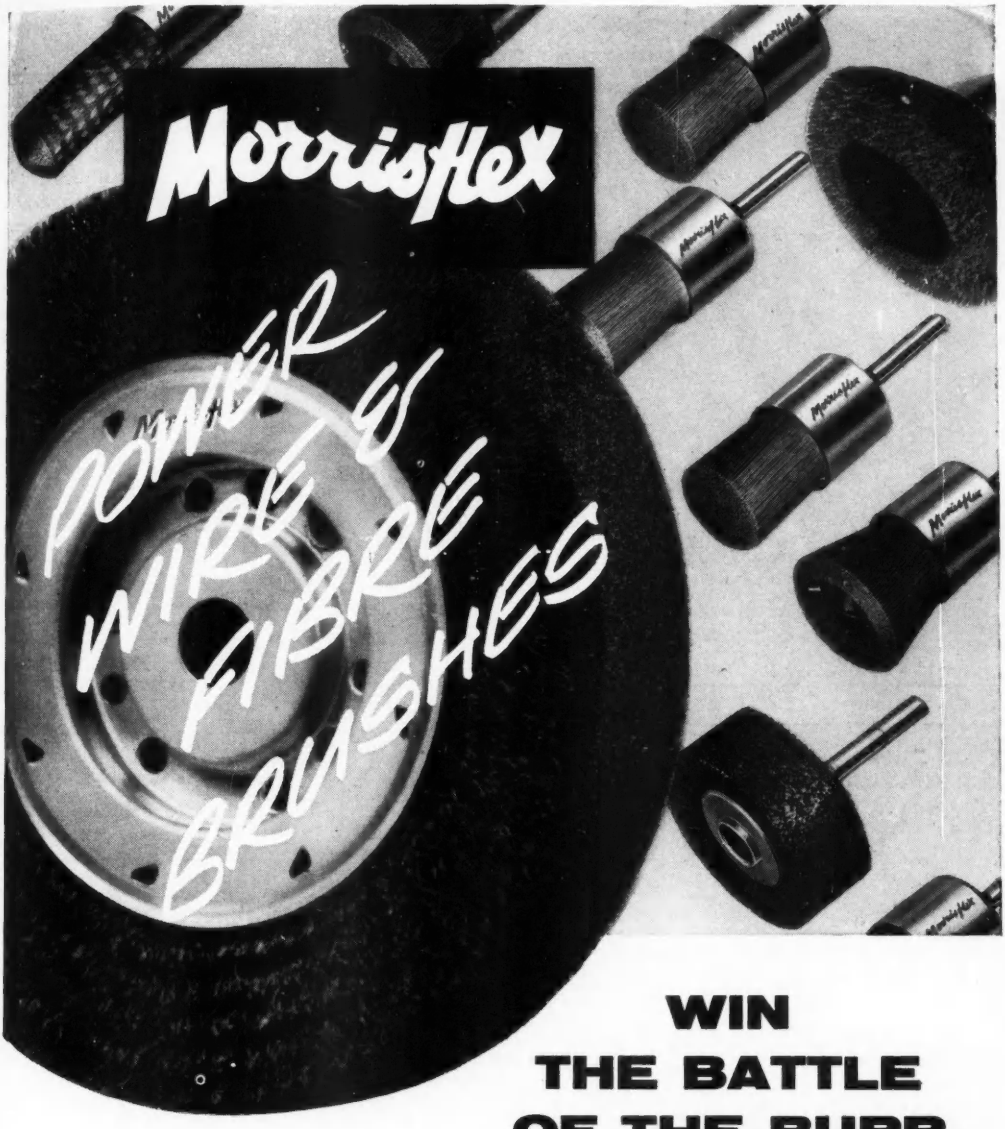
All are obtainable free on request to:

THE WALPAMUR COMPANY LIMITED
DARWEN AND LONDON

Paints, Enamels, Varnishes and Finishes for every industrial need

BY APPOINTMENT
TO HER MAJESTY THE QUEEN
MANUFACTURERS OF PAINT

W849



WIN THE BATTLE OF THE BURR

B. O. MORRIS LTD. • MORRISFLEX WORKS, BRITON ROAD • COVENTRY

Telephone : 53333 (PBX) Telegrams : MORISFLEX, COVENTRY

PRODUCT OF THE Morrisflex GROUP

THOMAS CHATWIN & CO.

for 100 per cent accuracy

in making form tool cutters of all types. We have over a century of experience in precision engineering and non-standard flat and spherical form cutters are our speciality.
Look for Chatwin. The name for a guarantee in precision and accuracy.

Write for a copy of "The Tool for the Job" a Chatwin Publication.

Thomas Chatwin & Co.
Great Tindal Street
Birmingham 16
Phone : Edgbaston 3521
London Office: 25 Hanover Sq., W.1
'Phone: MAYfair 8783

Area Sales Offices in Bristol, Manchester & Newcastle-on-Tyne.

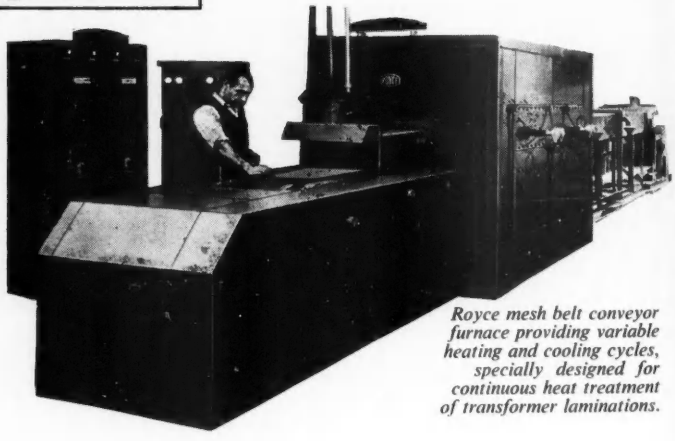
---

a ROYCE special

For stress relieving transformer laminations

A Royce furnace built to your special requirements costs no more than standard plant.

Judge for yourself. For your new furnace get a quotation from Royce.



Royce mesh belt conveyor furnace providing variable heating and cooling cycles, specially designed for continuous heat treatment of transformer laminations.

Normal working temperature—820°
Maximum operating temperature—1050°
Normal heating cycle—60 mins.

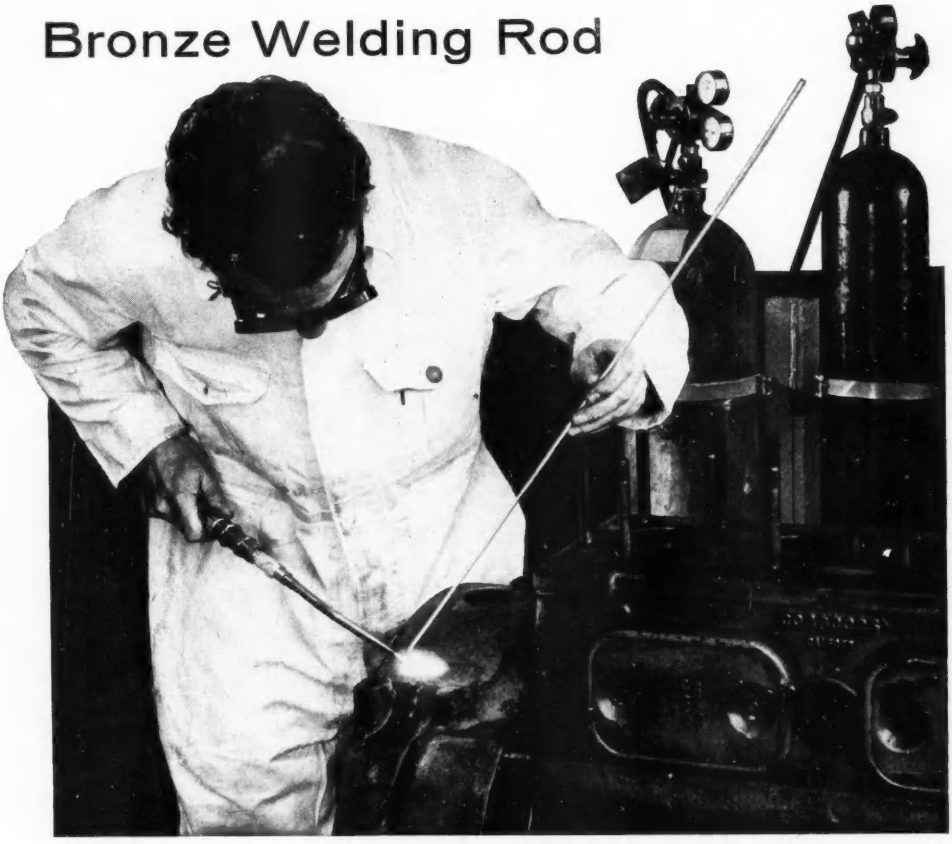
Average power consumption—
300 kwh per ton of laminations
Atmosphere—burnt town gas.

ROYCE

ROYCE ELECTRIC FURNACES LTD
Designers and manufacturers of furnaces, ovens & kilns for all industries
SIR RICHARD'S BRIDGE. WALTON-ON-THAMES. SURREY. Telephone: Walton-on-Thames 2577/8
4RP/RF 329

LINCOLN lead the field with the completely **NEW** Gas Welding Development **LECO No 1**

All purpose **FLUX COATED** Bronze Welding Rod



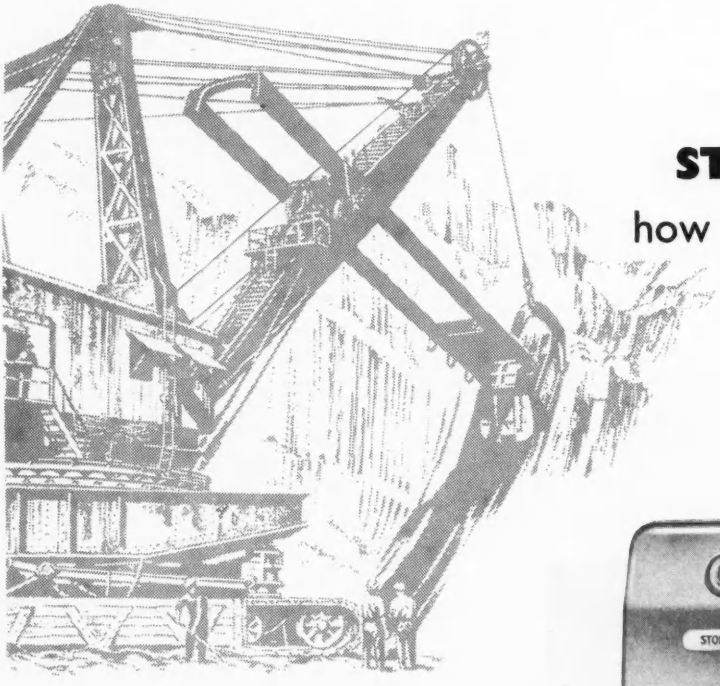
LE2

For further details of LECO No 1, the money-saving rod for oxy-acetylene welding and brazing, please write to:

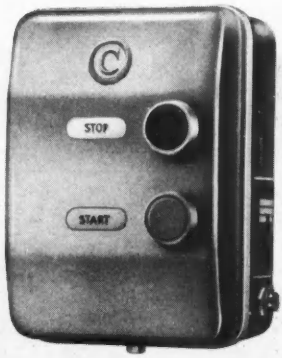
LINCOLN ELECTRIC CO LTD

A MEMBER OF THE GKN GROUP OF COMPANIES

Welwyn Garden City • Herts • Telephone: Welwyn Garden 920/4 • 4581/5



START
how you like . . .



CRABTREE SWITCH, *manufactured by J. A. Crabtree & Co. Ltd., finished in Stoving Finish Standard Quality.*

. . but "**FINISH**" with

LUXOL

There are twenty-one standard finishes in the famous LUXOL family. Almost certainly the finish best suited to your product and your assembly line is amongst them. Here are a few of the LUXOL family:—

LUXOL
Standard Stoving Finish

LUXOL
Quick Drying Finish

LUXOL
Wrinkle Finish

LUXOL
Cellulose Finish

LUXOL
Hammered Finish

LUXOL
Stoving Polychromatic Finish

LUXOL
Polyurethanes

EPILUX 2
Stoving Finish

Our Technical Advisory Service will gladly co-operate with you if your needs are not covered by our standard range and will, if necessary, formulate a Finish especially for you.

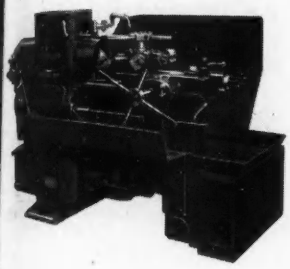
BY APPOINTMENT TO
HER MAJESTY QUEEN ELIZABETH II
MANUFACTURERS OF PAINT
BRITISH PAINTS LIMITED

BRITISH PAINTS LIMITED

Portland Road, Newcastle upon Tyne, 2
Northumberland House,
303-306, High Holborn, London, W.C.1.
31, Wapping, Liverpool

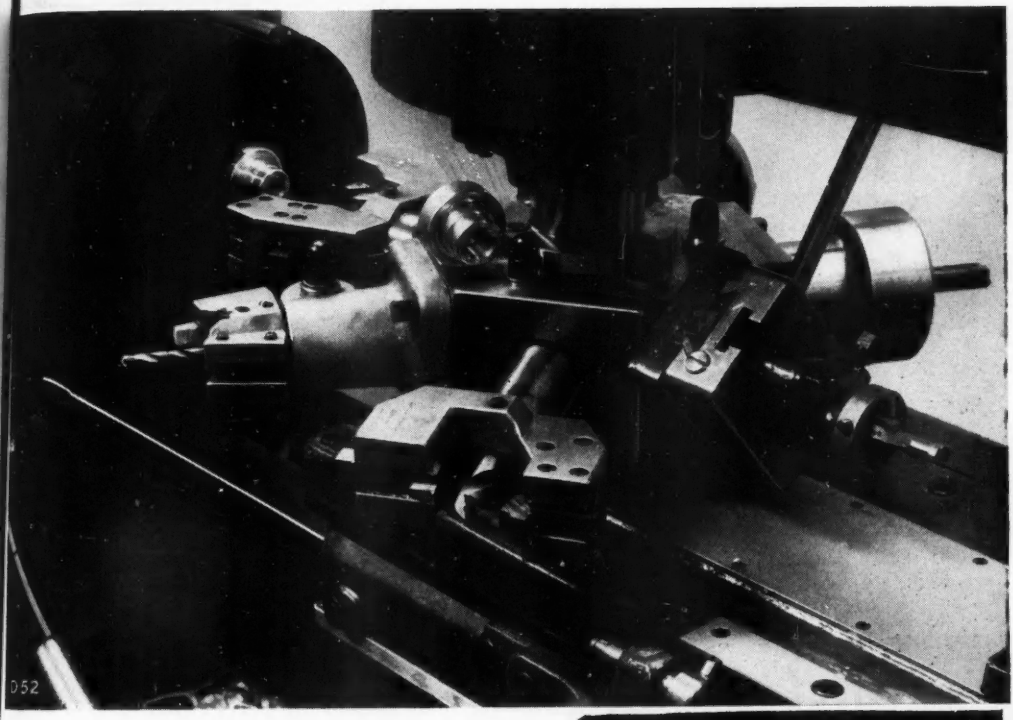
BELFAST, BIRMINGHAM, BRISTOL, CARDIFF, GLASGOW, LEEDS, MANCHESTER, NORWICH, PLYMOUTH, SHEFFIELD, SOUTHAMPTON, SWANSEA AND ALL PRINCIPAL TOWNS.

A FINE FINISH FOR EVERY PRODUCT



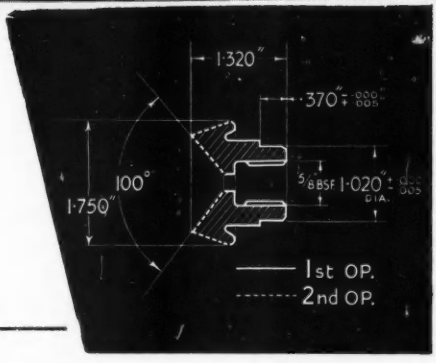
HERBERT

No. 2 Flashcap Lathe for efficient high production of non-ferrous threaded components requiring frequent spindle reversals



Magnesium alloy component shown is machined from blanks sawn from the bar, in two operations, on a Herbert Flashcap Lathe. Floor-to-floor times —29 seconds (1st op.), 11 seconds (2nd op.).

Now available for **Early Delivery**



ALFRED HERBERT LTD., COVENTRY

AD418

for ECONOMICAL MULTI-DRILLING

Consult the Specialists

We manufacture all types of multi-drilling equipment from a simple two-spindle adjustable model to a multi-head that will drill a large cylinder block in one operation. S.P.K. multi-heads are built-up from a range of standardized interchangeable spindle assemblies and housings, which have been developed as a result of many years' practical experience, resulting in the minimum cost and a proved performance.

SLACK & PARR LIMITED · KEGWORTH Nr. DERBY
Tel.: Kegworth 306

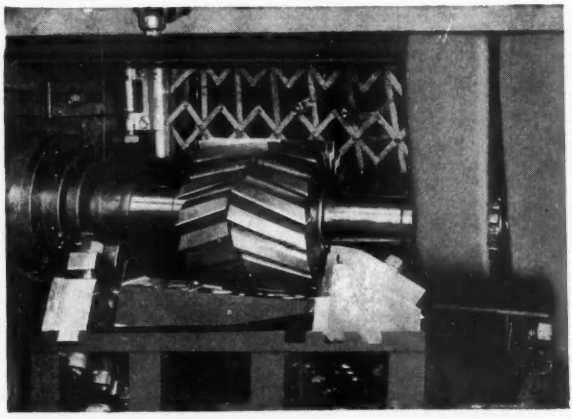
BRAYSHAW

Where quality and accuracy count

Metropolitan-Vickers Electrical Company Limited, Trafford Park, Manchester, specify Brayshaw Patent Interlocking Cutters for precision work in their Small Turbine Department.

Interlocking faces of wavy contour eliminate sharp internal angles or sudden changes of section, so that lines of weakness are not developed. Applied to form cutters this system permits substantial side relief resulting in freer cutting, increased output and cutter life.

Write to-day for further details.

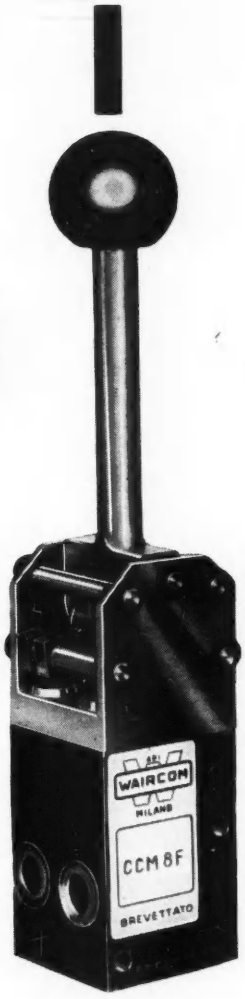


Brayshaw Cutters operating in the Small Turbine Department of Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester.

BRAYSHAW **PATENT INTERLOCKING CUTTERS**

BRAYSHAW TOOLS LTD. : BELLE VUE WORKS, MANCHESTER, 12.
Telephone: EASt 1046. *Telegrams*: HARDENING, MANCHESTER.
LONDON OFFICE: 21 LIVERPOOL ST., E.C.2. *Telephone:* AVENUE 1617-8.

API
WAIRCOM
di Dott. Ing. P. L. PANIGATI



milan,
italy

via maestri campionesi, 17
tel. 58.03.68

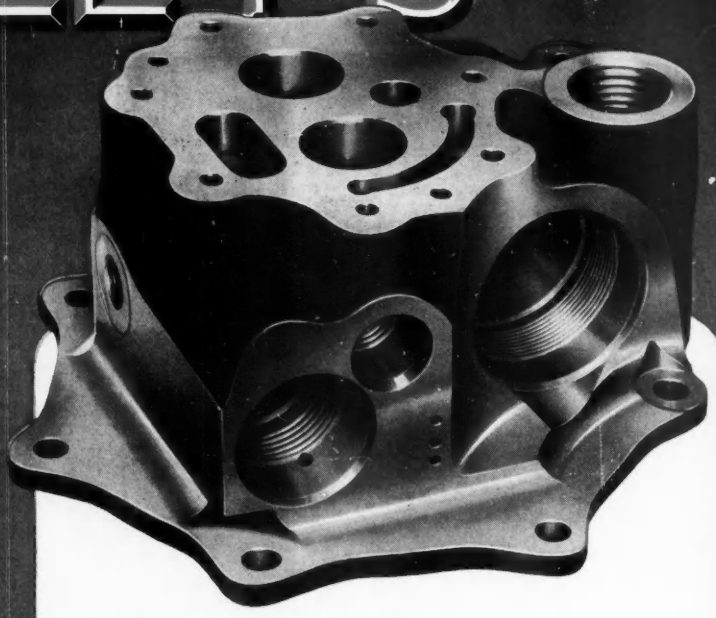
pneumatic

industrial

equipment

pneumatic controls
pneumatic valves
pneumatic cylinders
special couplings for compressed air
development of pneumatic plant

LEY'S



Tested at 2,500 p.s.i.

The illustration shows a valve body for use in hydraulic control equipment. The complex nature of this valve body involves a great deal of machining; at the same time high mechanical strength is an important factor, since the valves are used at a high working pressure and are tested at 2,500 p.s.i.

These considerations led to the choice of castings in 'Lepaz 35', a pearlitic malleable which combines excellent machinability with an ultimate stress of 33/38 tons sq. inch and an elongation of 6–8%.

LEY'S MALLEABLE CASTINGS CO. LTD., DERBY. TELEPHONE: DERBY 45671.

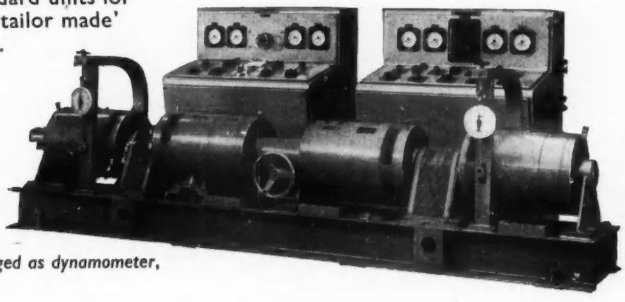
STRENGTH & RIGIDITY

LEY'S

POWER AND CONTROL

E.D.C.C. machines and control gear are available to meet most requirements. Standard units for straightforward applications and 'tailor made' specials for the most diverse uses.

Recently supplied to the Welsh College of Advanced Technology, Cardiff — a multiple motor generator set, comprising 4 machines and two control desks. The machine unit comprises:—



- *7h.p. D.C. variable speed motor, arranged as dynamometer, complete with Tacho-generator*
- *4kVA alternator*
- *4kVA alternator with rotatable stator*
- *7h.p. synchronous motor (left to right) arranged as dynamometer*
- *The complete unit can be split into two motor-alternator sets*

ELECTRO-DYNAMIC

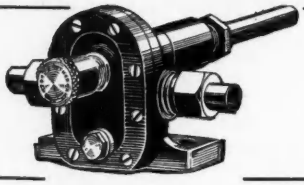
CONSTRUCTION COMPANY LIMITED

ST MARY CRAY KENT PHONE: ORPINGTON 27551 GRAMS: ELEDAMIC ST MARY CRAY

CONTROL GEAR DIVISION: BRIDGWATER SOMERSET TEL BRIDGWATER 2882 GLASGOW OFFICE. 40 HOULDSWORTH ST C3 TEL: CENTRAL 2620

P2827

GEAR PUMPS



You make the wisest choice when you decide on a GEAR PUMP by Rotherhams — the name is your guarantee of the built-in qualities you must have for the efficient year-in, year-out dependability that spells trouble-free performance.

Full information on Rotherham products, including the following, are yours for the asking.
Time Lags, Instruments, Recording Clocks, Process Timers, Pressure Gauge Movements, Small parts for Engineering, such as Taps, Oil and Grease Cups, Oil Indicators, Unions, Nipples and Olives.

Rotherhams OF COVENTRY

Rotherham & Sons Ltd., Coventry

Telephone: 64154

PRECISION MANUFACTURERS SINCE 1750

SO *THAT'S* THE SUCCESS SECRET OF

GENUINE Jubilee REGD. TRADE MARK

WORM DRIVE HOSE **CLIPS**

L. ROBINSON & CO., (Gillingham) LTD.,
LONDON CHAMBERS, GILLINGHAM, KENT. TEL. GILLINGHAM 51182/3

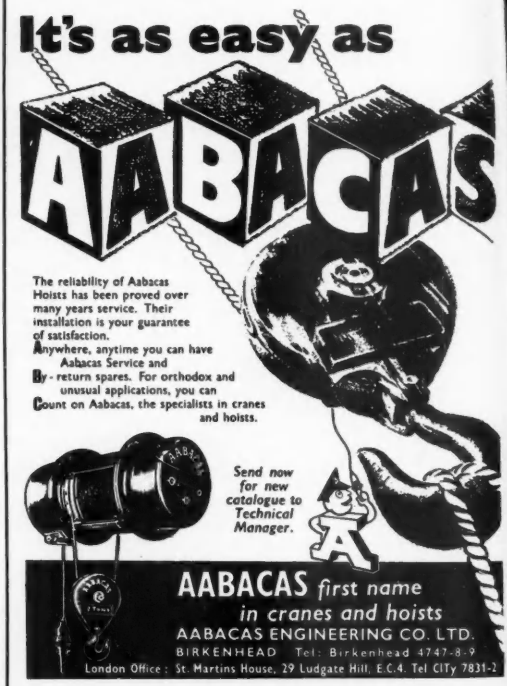
TO INDICATE CONTROL OR RECORD TEMPERATURE

For accuracy, ease of reading, robustness, economy and long, trouble free life install Rototherm Thermometers, Controllers and Recorders. Specialists in bi-metallic applications. Write for details.

Rototherm

BI-METAL MERCURY-IN-STEEL VAPOUR PRESSURE
THE BRITISH ROTOTHERM CO. LTD.
Merton Abbey, London, S.W.19 LIBerty 7661 (6 lines)
Midland Factory: Hollis Street, New Basford Nottingham 77847

It's as easy as AABACAS



The reliability of Aabacas Hoists has been proved over many years service. Their installation is your guarantee of satisfaction.
Anywhere, anytime you can have Aabacas Service and
By-return spares. For orthodox and unusual applications, you can
Count on Aabacas, the specialists in cranes and hoists.

Send now for new catalogue to Technical Manager.

AABACAS *first name in cranes and hoists*
AABACAS ENGINEERING CO. LTD.
BIRKENHEAD Tel: Birkenhead 4747-8-9
London Office: St. Martins House, 29 Ludgate Hill, E.C.4. Tel CITy 7831-2

PRECISION ENGINEERING
specialists in

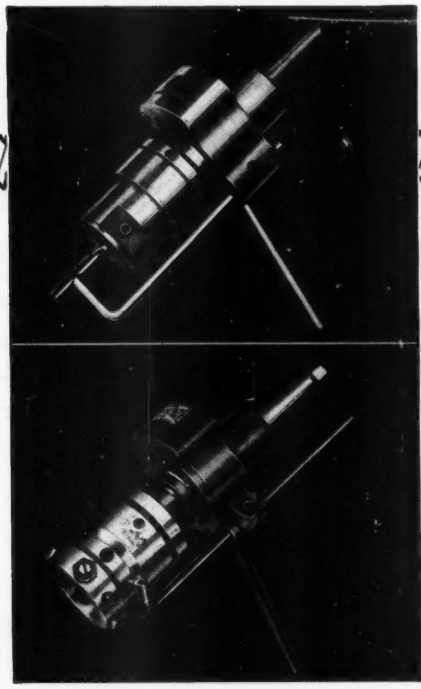
- ★ **light metal pressings and sections**
- ★ **stamping, forming, galvanising**
- ★ **argon and general welding**
- ★ **aluminium heat treated pressings**

Our varied experience in engineering techniques and "know how" on up-to-date production methods, combined with skilled personnel and modern machinery, enables us to say with confidence, that we are able to offer an unequalled service for the highest quality work, at the lowest possible prices, and reliable delivery.

LACON

Your enquiries are invited:
LIGHT ALLOY CONSTRUCTION LIMITED,
Mowden Hall, Darlington. Phone: Darlington 5226.
5a Dean's Yard, London, S.W.1. Phone: Abbey 1365.

the last word . . . .



PRECISION MADE SCREWING AND TAPPING ATTACHMENTS.

for efficiency in screwing

for efficiency in tapping

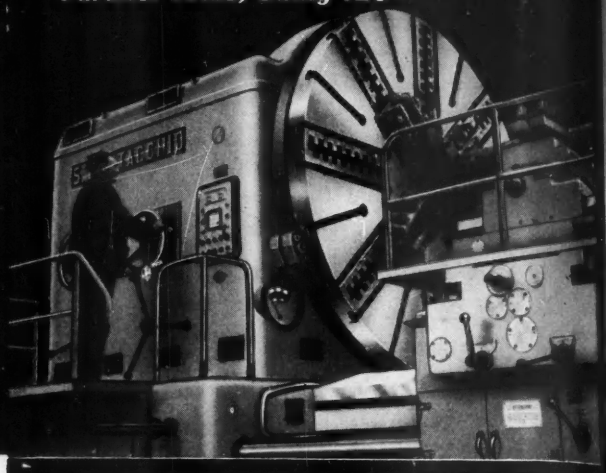
The new Ackworthie range of Friction Tappers, improved and perfected after many years of research can be used on any Drilling Machine—available on trial—Write for fully descriptive folder. Ackworthie Tapping attachments will tap and screw from 12 B.A. to 1½ in. dia. at a fraction of the cost of a new machine.

ACKWORTHIE

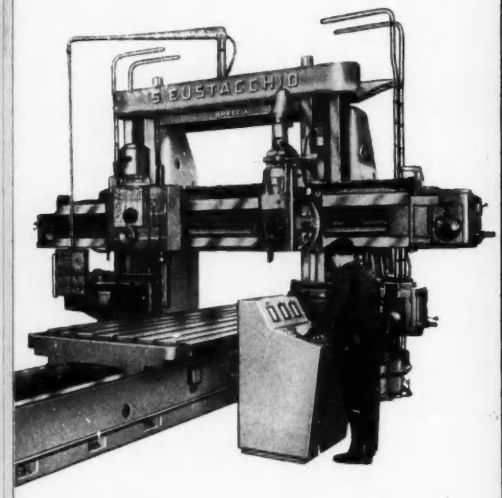
JOHN ACKWORTHIE LTD.,
Dalehouse Lane, Kenilworth, Warwickshire.
Telephone: Kenilworth 1530 (P.B.X.)

- Horizontal Lathes, Vertical Turning and Boring Mills, Face Lathes of heavy and medium size.
- Rolling Mill Roll Lathes. Special Roll Grooving Lathes with copying device.
- Rolling Mill and Paper Mill Roll Grinders.
- Heavy and medium size Planers.
- Heavy and medium Plano-Milling Machines.
- Crankshaft Roughing Lathes.
- Square, round and polygonal Ingot Lathes.

Parallel Lathe, swing 120"



Planer with planable width 80"

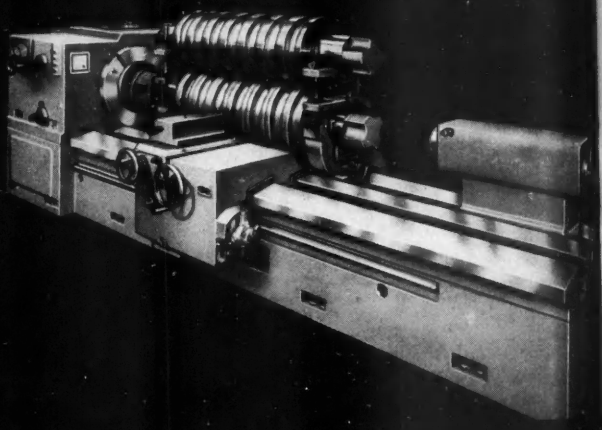


STABILIMENTI

BRESCIA (ITALY)

- Sheet Straightening Machines.
- Automatic Selfcompressor Hammers.
- Mechanical and Hydraulic Presses.
- Complete Rolling Mills for steels and soft metals.
- Designing and building of any special heavy machinery.
- Special cast iron rolls for rolling mills and for all industrial uses.
- Cast iron ingot moulds of all types and sizes.

Roll grooving and turning lathe, swing 28"



NEW MILLING TOOLS!

HIGH-SPEED STEEL
SCREW SHANK
END MILLS
(WITH EXCLUSIVE TOOTH FORM)

HIGH-SPEED STEEL
SCREW SHANK
SLOT DRILLS
(WITH EXCLUSIVE TOOTH FORM)

THE
'TITANIC'
CHUCK
(INCORPORATING MANY
NEW DESIGN FEATURES)

OSBORN

The superior design of these products is the result of prolonged research and development. They are far in advance of similar tools of comparable price and much faster speeds and feeds are achieved with the cutters.
Please write for leaflet No. 11 *"An Advance in Milling"*.

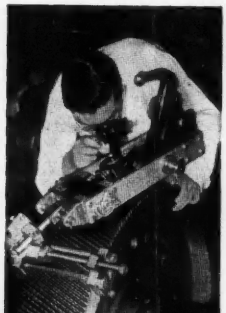
★*Comprehensive stocks constantly maintained*

SAMUEL OSBORN & CO., LIMITED
CLYDE STEEL WORKS · SHEFFIELD
Fine Steelmakers · Steelfounders · Engineers' Toolmakers

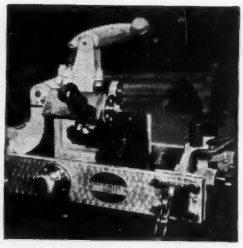
Taking the measure of

HARDNESS—

The Vickers Pyramid Hardness Testing Machine, compact in size and comprehensive in service, provides a simple and accurate method of metallurgical control at the place of production. Simple to operate, it can handle an unequalled range of work with exceptional accuracy.



The Vickers Portable Gear Hardness Tester combines the essential features of Pyramid Hardness testing with portability, enabling testing on the pitch line of gears, particularly in such places as ships, power stations, etc., where large gears cannot easily be moved.



The Vickers Portable Hardness Tester, specially developed from the standard machine, combining all its essential features with an extensive portability. It allows testing on all kinds of work—in the laboratory, on the shop floor in positions where large components cannot be moved.

All these machines are equipped with the standard Vickers Micrometer Ocular which, used in conjunction with the Vickers Pyramid Diamond Indenter, gives readings in the internationally recognised VPN.

Vickers Hardness Testers

Please send for a catalogue giving full details

VICKERS-ARMSTRONGS (ENGINEERS) LIMITED

13 City Road · London, E.C.1.

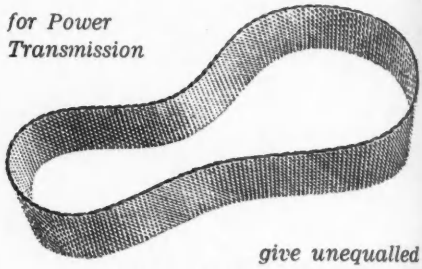
Tel: METropolitan 8877 : Telegrams: Vicksbox, Ave, London

TGA CH63

GRIPOLASTIC

ENDLESS BELTS

for Power Transmission



give unequalled performance **ON ALL DRIVES**

So.e Manufacturers:

LEWIS & TYLOR LTD

Power Transmission Engineers

GRIPOLY MILLS · CARDIFF

Tel: Cardiff 26301

and

Terminal House, Grosvenor Gardens, LONDON SW1

Tel: Sloane 7883

Water in your air lines?

VICTOR CAN HELP!

Please write for Booklet No. C. A. 100 to

VICTOR PRODUCTS (WALLSEND) LTD.,

WALLSEND-ON-TYNE

Index to Current Advertisers and their Advertising Agents

Aubacas Engineering Co. Ltd. A98
Agency—McConnell & Co. (Adv.) Ltd.
Abbey Panel and Sheet Metal Co. Ltd., The ..... —
Agency—Willington Advertising Ltd.
Ackworthie, John, Ltd. ..... A52 & A99
Agency—Biddle Bros. Ltd.
Acru Electric Tool Mfg. Co. Ltd. ..... —
A.E.W. Ltd. A48
Agency—G. Street & Co. Ltd.
Allspeeds Ltd. ..... —
Agency—Hyde & Partners Ltd.
Alumilite & Alzak Ltd. ..... —
Agency—Beresford Bourke Ltd.
Angus, George, & Co. Ltd. ..... —
Agency—Redheads Adv. Ltd.
Archdale, James, & Co. Ltd. A14
Armstrong Patents Co. Ltd. A24
Agency—Pickersgill Publicity Service Ltd.
Armstrong Siddeley (Brockworth) Ltd. ..... —
Agency—Young & Rubicam Ltd.
Armstrong, Stevens & Son Ltd. ..... —
Agency—Boswell, Barratt & Phillips Ltd.
Ashmore, Benson, Pease & Co. ..... —
Associated Electrical Industries Ltd. Cover 1 & A37
Agency—T.G.A. Ltd.
Automotive Engineering Ltd. ..... —
Agency—W. S. Crawford Ltd.
Avo Ltd. A66
Agency—National Publicity Co. Ltd.

B.I.P. Chemicals Ltd. A89
Agency—Central News Ltd.
B.R.C. Engineering Co. Ltd. A9
Agency—Murray Watson Ltd.
B.R.D. Company Ltd. A76
Agency—A. A. Black Ltd.
B.S.A. Tools Ltd. ..... —
B.T.R. Industries Ltd. ..... —
Agency—Dorland Advertising Ltd.
Balfour, Arthur, & Co. Ltd. ..... —
Agency—Charles Stanley & Partners Ltd.
Ballinger, L. J. H., Ltd. ..... —
Barwell, James, Ltd. ..... —
Agency—Beardmore Adv. Ltd.
Beakbane, Henry (Fortox) Ltd. ..... —
Berardi, Rino Officine ..... —
Birfield Group A69, A70, A83
Agency—Central News Ltd.
Birwelco Ltd. ..... —
Agency—Grosvenor Advertising Ltd.
Blackheath Stamping Co. Ltd. A41
Agency—Maurice G. Parker Ltd.
Borg & Beck Co. Ltd. A34
Agency—H. Raymond Morgan
Brammer, H., & Co. Ltd. ..... —
Agency—Harrisons Advertising Ltd.
Brayshaw Tools Ltd. A60
Agency—Ingham Butterworth Ltd.
British Bellows A32
Agency—Elliott Advertising Ltd.
British Electric Resistance Co. Ltd. ..... —
Agency—John Mitchell & Partners Ltd.
British Geon Limited ..... —
Agency—T. G. Scott & Son Ltd.
British Manzel Oil Pump Co. ..... —
British Paints Ltd. A58
Agency—Redheads Adv. Ltd.
British Power Transformer Co. Ltd. ..... —
Agency—John Mitchell & Partners Ltd.
British Rolling Mills Ltd. ..... —
Agency—Maurice G. Parker Ltd.
British Rototherm Co. Ltd., The A98
Agency—Pitchford's Advertising Ltd.
British Thompson-Houston Co. Ltd., The ..... —
Agency—T.G.A. Ltd.
British Timken: Division of The Timken Roller Bearing Co. A85
Agency—H. Raymond Morgan
Broadbent & Co. (Rochdale) Ltd. A24
Agency—Arthur Burns Publicity
Broady, William, & Son Ltd. A92
Agency—Harrisons Adv. Ltd.
Brockhouse, J., & Co. Ltd. ..... —
Agency—A. N. Holden & Co. Ltd.
Bronx Engineering Co. Ltd. ..... —
Agency—A. N. Holden & Co. Ltd.

Brown, Boveri, & Co. Ltd. A94
Brown, David, Corporation (Sales) Ltd., The A7
Agency—Oelrichs Advertising Ltd.
Brown Fintube (Great Britain) Ltd. ..... —
Agency—Grosvenor Advertising Ltd.
Brown, N. C. Ltd. ..... —
Agency—Farmer Advertising Ltd.

Carter, Gears Ltd. ..... —
Castings Ltd. ..... —
Agency—Rowlinson Broughton Ltd.
Centec Machine Tools Ltd. ..... —
Agency—Applied Designs Adv. Ltd.
Chapman & Hall Ltd. 526
Chatwin, Thomas, & Co. A56
Agency—A. N. Holden & Co. Ltd.
Chinn, J. S., & Co. Ltd. ..... —
Churchill, Charles, & Co. Ltd. ..... —
Agency—Technical Advertising Service Ltd.
Churchill Machine Tool Co. Ltd., The ..... —
Agency—Associated British Machine Tool Makers Ltd.
Clarkson (Engineers) Ltd. A93
Agency—Nicholls, Dorrity Adv. Ltd.
Colt Ventilation Ltd. ..... —
Agency—Greenlys Ltd.
Consolidated Pneumatic Tool Co. Ltd. A20
Agency—Crane Publicity Ltd.
Coppier Fratelli ..... —
Coulthard, Wm. & Company Ltd. A12
Cradley Boiler Co. Ltd. ..... —
Agency—Riley Advertising Ltd.
Crofts (Engineers) Ltd. A65
Cronite Foundry Co. Ltd., The ..... —
Crowthorn Engineering Co. Ltd. A8
Agency—J. K. Clayton Advertising Ltd.

Dart Spring Co. Ltd. ..... —
Agency—Beardmore Adv. Ltd.
Darwins Ltd. ..... —
Agency—Apex Advertising Ltd.
Dawson Bros. Ltd. ..... —
Agency—Collinson's Adv. Agency Ltd.
Delapena & Son Ltd. ..... —
Agency—S. D. Toon & Heath Ltd.
Deloro Stellite Ltd. A17
Dick, R. & J., Ltd. ..... —
Agency—Rex Publicity Ltd.

Eagle Pencil Co. ..... —
Agency—Saward Baker & Co. Ltd.
Elcontrol Ltd. A44
Agency—Fdk. E. Potter Ltd.
Electrical Development Association ..... —
Agency—Mather & Crowther Ltd.
Electric Resistance Furnace Co. Ltd. ..... —
Agency—Nigel Rainbow & Partners Ltd.
Electrical Power Engineering Co. (B'ham) Ltd. A36
Agency—Nicholls, Dorrity Advertising Ltd.
Electro-Dynamic Construction Co. Ltd. A97
Agency—J. Peers & Associates Ltd.
Elliott, E., Ltd. A45
Agency—Sterling Advertising Ltd.
Ellison, George Ltd. ..... —
Agency—Crossley & Co. Ltd.
Empyrium Welding & Mfg. Co. Ltd. A16
Agency—Jack White & Assocs. Ltd.
English Electric Co. Ltd., The ..... —
Agency—Technical Advertising Service Ltd.
English Steel Tool Corporation A43
Agency—T.G.A. Ltd.
E.N.V. Engineering Co. Ltd. A18
Agency—Allardyce Palmer Ltd.
Esso Petroleum Co. Ltd. ..... —
Agency—McClann-Erickson, Adv. Ltd.
Eustacchio, S. A100

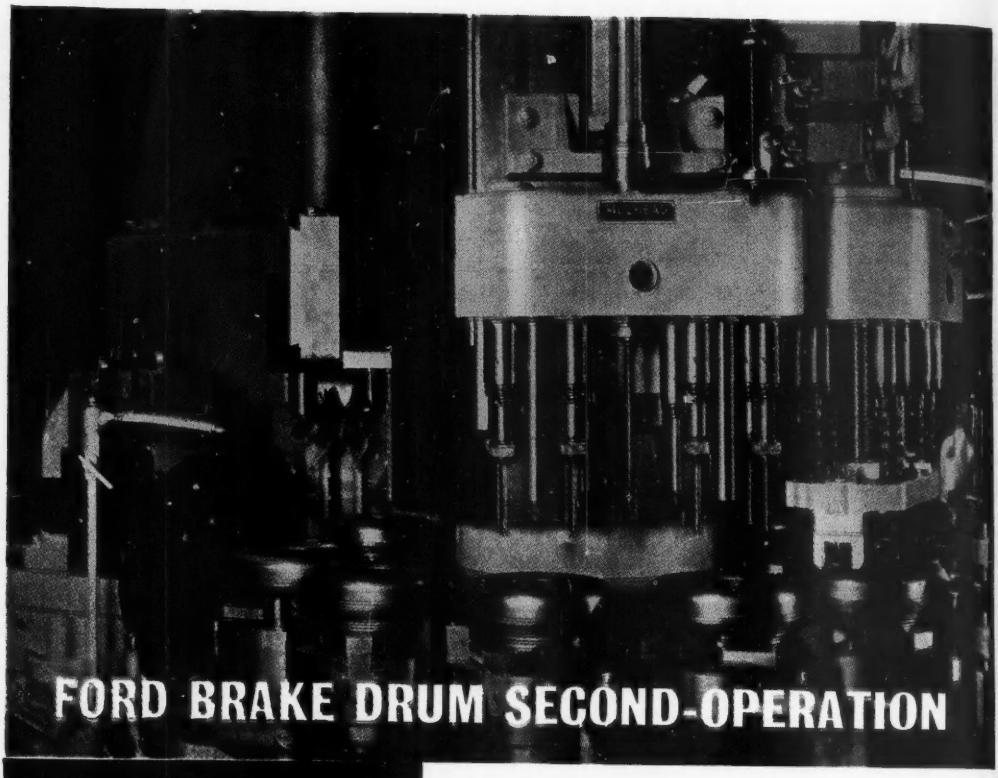
Fafnir Bearing Co. ..... —
Agency—H. Raymond Morgan
Farrar Boilerworks Ltd., The ..... —
Agency—Harrisons Advertising Ltd.
Fel-Electric Ltd. ..... —
Agency—Oelrichs Advertising Ltd.
Fenner, J. H., & Co. Ltd. ..... —
Agency—Hyde & Partners Ltd.

Fenton, Byrn & Co. Ltd. ..... —
Agency—J. Peers Associates Ltd.
Festo-Maschinenfabrik ..... —
Firth-Derihon Stampings Ltd., The A10
Agency—Stanley D. Dickson
Firth, Thos., & John Brown Ltd. ..... —
Agency—Stanley D. Dickson
Flame Hardeners Ltd. ..... —
Flexello Castors & Wheels Ltd. ..... —
Agency—Dudley Turner & Vincent Ltd.
Ford Motor Co. Ltd. A11
Agency—Rumble Crowther & Nicholas Ltd.
Francis, Wm. C., Ltd. ..... —
Fraser, Andrew, & Co. Ltd. ..... Cover 2
Agency—J. Peers and Associates Ltd.
Fry's Metal Foundries Ltd. A68
Agency—Max Ritson & Partners Ltd.

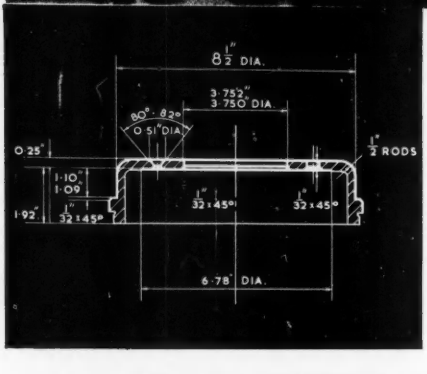
Gas Council, The ..... Cover 4
Agency—C. P. Wakefield Ltd.
General Electric Co. Ltd. ..... —
Agency—Kingscott Ltd.
Glacier Metal Co. Ltd. A19
Agency—Notley Advertising Ltd.
Gloucester Foundry Ltd. ..... —
Agency—Print for Industry Ltd.
Goodman, George, Ltd. ..... —
Agency—John Mitchell & Partners Ltd.
Goodyear Tyre & Rubber Co. (G.B.) Ltd., The A88
Agency—Erwin Wasey Ruthrauff & Ryan Ltd.
G.P.A. Tools & Gauges Ltd. ..... —
Griffiths, Gilbart, Lloyd & Co. Ltd. ..... Cover 3
Agency—Nicholls, Dorrity Advertising Ltd.
G.W.B. Furnaces Ltd. ..... —
Agency—Crane Publicity Ltd.

Hackbridge & Hewittic Electric Co. Ltd. A47
Agency—Industrial Publicity Service Ltd.
Haddon, Thomas, & Stokes Ltd. 524
Hadfields Ltd. ..... —
Hallmac Tools Ltd. A25
Agency—Jack White & Associates
Hancock & Co. (Engineers) Ltd. ..... —
Agency—Tibbenham Publicity Ltd.
Harcourt, David, Ltd. A24
Agency—Allardyce Palmer Ltd.
Hardy Spicer Ltd. ..... A70 & A83
Agency—Central News Ltd.
Harper, John, & Co. Ltd. A49
Agency—Rowlinson-Broughton Ltd.
Harris Tools, John, Ltd. ..... —
Agency—Sandbrook, Metcalf & Co. Ltd.
Hawker Siddeley Brush Turbines Ltd. A84
Agency—G. Street & Co. Ltd.
Heap, Joshua, & Co. Ltd. ..... —
Heenan & Froude Ltd. A22
Agency—Kenley Advertising Ltd.
Herbert, Alfred, Ltd. A59
Hermetic Rubber Co. Ltd. A40
Hibon, G. A82
Hilger & Watts Ltd. ..... —
Agency—Crane Publicity Ltd.
Hindle, Joshua, & Son Ltd. ..... —
Agency—Storey Evans Advertising
Hoffmann, Mfg. Co. Ltd., The A51
Holden, Arthur, & Sons Ltd. A48
Agency—S.D. Toon & Heath Ltd.
Holroyd, John, & Co. Ltd. ..... —
Agency—C. R. Casson Ltd.
Horstmann Gear Co. Ltd., The ..... —
Agency—Trowbridge Pritchard & Co. Ltd.
Hydraulics & Pneumatics Ltd. ..... —
Agency—Edward Hilton Advertising Ltd.

Ideal Fabbrica Italiana Trapani ..... —
Ilford Ltd. ..... —
Agency—Samson Clark & Co. Ltd.
Ina Needle Bearings Ltd. ..... —
Agency—Creighton Griffiths Ltd.
Indusmond Ltd. ..... —
Agency—Arks Publicity Ltd.
Industrial Fan & Heater Co. Ltd. A1
Agency—Sinclair Advertising Agency



FORD BRAKE DRUM SECOND-OPERATION



MACHINED IN 40 SECONDS

The use of special Mulhead multi-drill heads on the Ryder Verticalauto enables drilling, reaming, countersinking and back-chamfering operations to be performed in addition to standard boring and facing work.

The second operation on this Ford Brake Drum is completed at very high output rates on this 12-spindle No. 10 Ryder Verticalauto.

Ryder **VERTICALAUTO**

Thos. Ryder & Son, Limited, Turner Bridge Works, Bolton, England.
Makers also of single spindle Rydermatics and Piston Ring Lathes.

Index *(continued)*

Ingersoll-Rand Co. Ltd. A27
Agency—J. Peers & Assocs. Ltd.

Innocenti ..... —

International Combustion Products Ltd. ..... —
Agency—T.G.A. Ltd.

International Mechanite Metal Co. Ltd. ..... —

Jenkins, Robert, & Co. Ltd. A35
Agency—W. Hopwood & Co. Ltd.

Jerguson Tress Gauge & Valve Co. Ltd. ..... —
Agency—J. Peers & Associates Ltd.

Jet-Lube Ltd. A6

Johnson Foster, H., Ltd. ..... Cover 3
Agency—Pickersgill Publicity Service Ltd.

Johnson Precision Instruments (Newman Granger) Ltd. ..... —
Agency—Rex Publicity Service Ltd.

Joyner, Ellison, & Co. Ltd. A13
Agency—Stowe & Bowden Ltd.

Keelavite Hydraulics Ltd. ..... —
Agency—Cogent Advertising Service Ltd.

Kendall & Gent Ltd. A28
Agency—Associated British Machine Tool Makers Ltd.

Kenilworth Manufacturing Co. Ltd. ..... —
Agency—Crossley & Co. Ltd.

Klaxon Ltd. A44
Agency—John Mitchell & Partners Ltd.

Lang Pneumatic Ltd. ..... —
Agency—J. Peers and Associates Ltd.

Laycock Engineering Ltd. A69
Agency—Central News Ltd.

Lewis Spring Co. Ltd., The 522
Agency—Longleys & Hoffmann Ltd.

Lewis & Tylor Ltd. A102
Agency—Glovers Advertising Ltd.

Lay's Malleable Castings Co. Ltd. A62
Agency—H. Raymond Morgan

Light Alloy Construction Ltd. A99
Agency—Print for Industry Ltd.

Lincoln Electric Co. Ltd. A57
Agency—London Press Exchange Ltd.

Lodge Plugs Ltd. A92
Agency—Elliott Advertising Ltd.

Logos, S. A. S. ..... —

Magnetic Valve Co. Ltd., The ..... —
Agency—John Westwood Ltd.

Maddings, W. J., Ltd. A106
Agency—Ripley, Preston & Co. Ltd.

Mercedes-Benz A78

Mercer, Thos. (Air Gauges), Ltd. A15
Agency—Nigel Rainbow & Partners Ltd.

Metal Products Limited A72
Agency—Lee Advertising Co. Ltd

Metalastik Ltd. A71

Midland Industries Ltd. A23
Agency—A. A. Black Ltd.

Minganti, G. ..... —

Mirrlees, Bickerton & Day Ltd. ..... —
Agency—Rowlinson-Broughton Ltd.

Mollart Engineering Co. Ltd. 478
Agency—J. Peers & Assocs. Ltd.

Mond Nickel Co. Ltd. A77
Agency—TGA Ltd.

Monks & Crane Ltd. ..... —
Agency—Sandbrook, Metcalf & Co. Ltd.

Morgan Crucible Co. Ltd., The A53

Morris, B. O., Ltd. A55
Agency—Cogent Advertising Service Ltd.

Mountford, Frederick (B'ham) Ltd. ..... —
Agency—S. D. Toon & Heath Ltd.

Mullard Equipment Ltd. ..... —

Neill, James, & Co. (Sheffield) Ltd. A87
Agency—J. K. Clayton Adv. Agency Ltd.

Newall, A. P., & Co. Ltd. A42
Agency—Osborne-Peacock Co. Ltd.

Newall Group Sales Ltd. ..... —
Agency—J. Peers and Associates Ltd.

Newbold & Bullford Ltd. ..... —
Agency—Hatton Press Ltd.

Nitralloy Ltd. 523
Agency—Stanley D. Dickson

North British Rubber Co. Ltd. ..... —
Agency—Robert Freeman & Co. Ltd.

Nu-Way Heating Plants Ltd. ..... —
Agency—Sinclair Advertising Ltd.

Osborn, Samuel, & Co. Ltd. A101

Ozalid Co. Ltd. A79
Agency—Oatley Webster Ltd.

P.R. Motors Ltd. A75
Agency—A. A. Black Ltd.

Parmiter, Hope & Sugden Ltd. A38
Agency—Donald Macdonald (Advertising) Ltd.

Perry Barr Metal Co. Ltd. ..... —
Agency—Tom C. Gough and Partners Ltd.

Pioneer Oilsealing & Moulding Co. Ltd. A30
Agency—Hyde & Partners Ltd.

Pitman, Sir Isaac, & Sons Ltd. A63

Pollard Bearings Ltd. ..... —
Agency—Hedley, Byrne & Co. Ltd.

Polypenco Ltd. ..... —
Agency—Lee Advertising Co. Ltd.

Powder Couplings Ltd. A74
Agency—Dryden-Allen Ltd.

Power-Gas Corporation Ltd. ..... —

Ransome & Marles Bearing Co. Ltd. ..... —
Agency—Ruddocks Advertising Agency

Refined Iron Co. (Darwen) Ltd. ..... —
Agency—Stowe & Bowden Ltd.

Renold Chains Ltd. ..... —

Reynolds Tube Co. Ltd. ..... —
Agency—Ripley, Preston & Co. Ltd.

Richards, Charles, & Sons Ltd. A52
Agency—Longleys & Hoffmann Ltd.

Roberts, J. W., Ltd. ..... —
Agency—Armstrong-Warden Ltd.

Robinson, L., & Co. (Gillingham) Ltd. A98
Agency—Ripley Preston & Co. Ltd.

Rocol Ltd. ..... —
Agency—Nevin D. Hirst (Advertising) Ltd.

Rocco, S. A33

Rotherham & Sons Ltd. A98
Agency—George Murray Advertising Ltd.

Royce Electric Furnaces Ltd. A56
Agency—Nigel Rainbow & Partners

Rubert & Co. Ltd. ..... —

Ryder Thos., & Son Ltd. A104
Agency—W. S. Crawford Ltd.

S.A.F.E. ..... —

S.A.I.M.P. ..... —

Salter, Geo. & Co. Ltd. ..... —
Agency—Severn Publicity Ltd.

Sanderson, Bros. & Newbould Ltd. A26

Saturn Industrial Gases Ltd. ..... —
Agency—Crossley & Co. Ltd.

Savery, Thomas, Pumps Ltd. ..... —
Agency—Boswell, Barrett & Phillips Ltd.

Schrader's Son, A. A21
Agency—Godbolds Limited

Self-Changing Gears Ltd. ..... —

Serck Radiators Ltd. A29
Agency—Longleys & Hoffmann Ltd.

Sheffield Twist Drill & Steel Co. Ltd., The A96

Sintered Products Limited ..... —
Agency—W. S. Crawford Ltd.

Slack & Parr Ltd. A60
Agency—Rex Publicity Service Ltd.

Smith, S., & Sons (England) Ltd. A80
Agency—Allardyce Palmer Ltd.

Spencer Wire Co. Ltd. ..... —
Agency—Divers Advertising

Sperry Gyroscope Co. Ltd. ..... —
Agency—Samson Clark & Co. Ltd.

Standard Telephones & Cables Ltd. A39
Agency—Brockie Haslam & Co.

Steel, J. M., & Co. Ltd. ..... —
Agency—Revnell & Son Ltd.

Steele & Cowlishaw Ltd. A74
Agency—Nevin D. Hirst Adv. Ltd.

Sterling Metals Ltd. ..... —
Agency—T. G. Scott & Son Ltd.

Stone-Wallwork Ltd. ..... —
Agency—Holman Advertising Ltd.

Super Oil Seals & Gaskets Ltd. ..... —
Agency—A. A. Black Ltd.

Sykes, W. E., Ltd. A50
Agency—W. S. Crawford Ltd.

Taylor, Taylor & Hobson Ltd. ..... —
Agency—Frank Gayton Advertising Ltd.

Technical Applications Ltd. ..... —
Agency—Alfred Bates & Son Ltd.

Teddington Industrial Equipment Ltd. ..... —
Agency—Crane Publicity Ltd.

Terry, Herbert, & Sons Ltd. A46
Agency—John Haddon & Co. Ltd.

Thorp, Thomas, & Co. Ltd. A106
Agency—J. Peers & Assoc. Ltd.

Thorpe, F. W., Limited A38
Agency—S. D. Toon & Heath Ltd.

Thompson, John, Water Tube Boilers Ltd. ..... —
Agency—Rowlinson-Broughton Ltd.

Titanium Metal & Alloys Ltd. ..... —
Agency—Alfred Bates & Son Ltd.

Torrington Co. Ltd., The A73
Agency—Osborne Peacock Co. Ltd.

Tress Engineering Co. Ltd. A2
Agency—J. Peers & Assocs. Ltd.

Tufnol Ltd. ..... —
Agency—Crossley & Co. Ltd.

Turner Brothers Asbestos Co. Ltd. ..... —
Agency—Donald Macdonald (Advertising) Ltd.

United Dominions Trust (Commercial) Ltd. A86
Agency—St. James Adv. & Publicity Co. Ltd.

United States Metallic Packing Co. Ltd. ..... —
Agency—Wm. Furness Ltd.

Uni-Tubes Ltd. ..... —
Agency—Frederick Aldridge Ltd.

Varatio-Strateline Gears Ltd. A72

Varley F.M.C. Ltd. ..... —
Agency—J. Peers & Associates Ltd.

Vaughan, Edgar, & Co. Ltd. A31
Agency—Oldfield & Sharp

Vickers Armstrongs (Engineers) Ltd. A102
Agency—T.G.A. Ltd.

Victor Products (Wallsend) Ltd. ..... A4 & A102
Agency—Doig Advertising Ltd.

Vokes Ltd. A90
Agency—Crane Publicity Ltd.

Waircom A61

Wakefield-Dick Industrial Oils Ltd. A3
Agency—Dorland Adv. Ltd.

Walker, Crosweller & Co. Ltd. ..... A67 & A81
Agency—Beardmore Advertising Ltd.

Walpamur Co. Ltd., The A54
Agency—Osborne-Peacock Co. Ltd.

Ward (Metal Details) Ltd. A32
Agency—Beardmore Advertising Ltd.

Weathershields Ltd. ..... —
Agency—Oldfield & Sharp

Welconstruct Co. Ltd. ..... —
Agency—Mundy, Gilbert & Troman Ltd.

Wellman Bibby Co. Ltd. A36

Wellworthy Ltd. A64
Agency—Erwin Wasey, Ruthrauff & Ryan Ltd.

Wharton Crane & Hoist Co. Ltd. ..... —
Agency—Henry Pybus Ltd.

Whitehouse Industries Ltd. ..... —
Agency—Hedley Byrne & Co. Ltd.

Whittaker Hall & Co. (1929) Ltd. ..... —
Agency—Ingham Butterworth Ltd.

Wicksteed, Charles, & Co. (1920) Ltd. A40
Agency—Nicholls, Dorrity Advertising Ltd.

Wiggin, Henry, & Co. Ltd. ..... —
Agency—T.G.A. Ltd.

Wild-Barfield Electric Furnaces Ltd. ..... —
Agency—Crane Publicity Ltd.

Williams, John, of Cardiff Ltd. A4
Agency—Glovers Adv. Ltd.

Wolverhampton Diecasting Co. Ltd., The A5
Agency—Sterling Advertising Ltd.

Woodside Die Sinking Co. Ltd. A91
Agency—F. C. Pritchard Wood & Partners Ltd.

Workington Iron & Steel Company ..... —
Agency—Rowlinson-Broughton Ltd.

View with cover removed.

MEDDINGS
Pacera

AIR HYDRAULIC UNIT DRILL HEAD SERIES I

OVERALL WIDTH (with cover) ONLY $4\frac{3}{16}$"

Specially designed for light, high-precision work. Specification includes the following features . . .

★ 4 SPINDLE SPEEDS—MAXIMUM 10,000 R.P.M.
★ INFINITELY VARIABLE FAST APPROACH AND FEED.
★ RAPID OPERATION—FAST APPROACH AND RETURN AT RATE OF 12" PER SECOND
★ VERY LOW AIR CONSUMPTION
★ DRILLING CAPACITY—$\frac{5}{32}$" IN ALUMINIUM, $\frac{3}{32}$" IN STEEL

Write for full particulars to the Manufacturers

W. J. MEDDINGS LTD

IPSWICH ROAD, TRADING ESTATE, SLOUGH, BUCKS. Tel: SLOUGH 22396

THORP EQUIPMENT FOR THE GAS INDUST

GAS FLOW INDICATORS

Direct Reading, variable aperture type, from 0 to 150 lb./sq. inch.

For all types of gases; can be calibrated to customers' requirements. Brass body, stoved black crinkle finish.

Cast Iron Body for Corrosive Gases.

Scale Plate in black crinkle, chrome or polished brass.

All Unions, etc., chrome plated.

Stainless Steel Float, in clear glass tube.

Customers when ordering should state—
(*a*) Specific Gravity and Working Pressure.
(*b*) Maximum and Minimum Rates of Flow.

Size B.S.P. ins.	Max. Cap. Cu. ft. Coal Gas 5/10"
$\frac{1}{4}$	80
$\frac{3}{8}$	60
$\frac{1}{2}$	110
$\frac{3}{4}$	230
1	420
$1\frac{1}{4}$	650
$1\frac{1}{2}$	900
2	1600
$2\frac{1}{2}$	2500

THOMAS THORP & CO LTD
WHITEFIELD Manchester

CAPSTAN AND AUTOMATIC PRODUCTIONS

SPECIALIST MACHINING AND GRINDING

CENTRELESS GRINDING

DEEP DRAWN DRAWING

G·G·L

LARGE AND SMALL PRESSING

You can count on

GRIFFITHS, GILBART, LLOYD. & CO. LTD.

EMPIRE WORKS, PARK ROAD, BIRMINGHAM 18

Telephone: Northern 6221

ANY METAL ANY QUANTITY

STAINLESS STEEL
HEAT RESISTING

ABRASIVE RESISTING
HEAT & ABRASIVE RESISTING

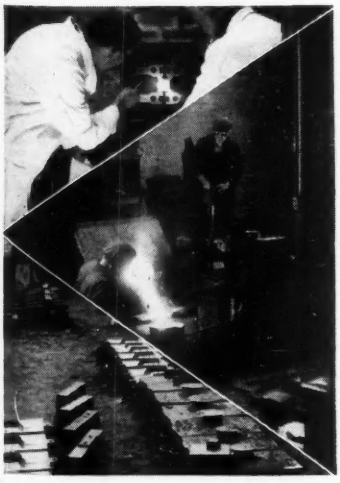
JOFO

CHROMIUM STEELS

MAGNET STEELS

CYANIDING POTS
CASE HARDENING BOXES
CAST IRON, BRASS, GUN METAL
PHOSPHOR BRONZE, ALUMINIUM etc.

HIGH SPEED TOOL, DIE & SPECIAL ALLOY STEELS
also STAINLESS STEEL ROAD LINES, STUDS & SIGNS . . .



HIGHLY ALLOYED STEEL

CASTINGS

'JOFO' castings are available in a wide range of qualities

From a few ozs up to 10 cwts each

M.O.S. approved inspection facilities installed
Routine X-ray control

H. Johnson Foster Ltd

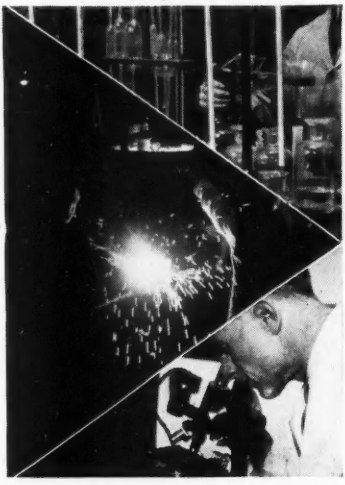
Regd. Office and Works:
BROADFIELD RD., SHEFFIELD 8.
Telephones: 52431/4

Office and Works Entrance:
AIZLEWOOD RD., SHEFFIELD 8.

Foundry : Aizlewood Road, Sheffield
Machine Shops : Broadfield Road, Sheffield

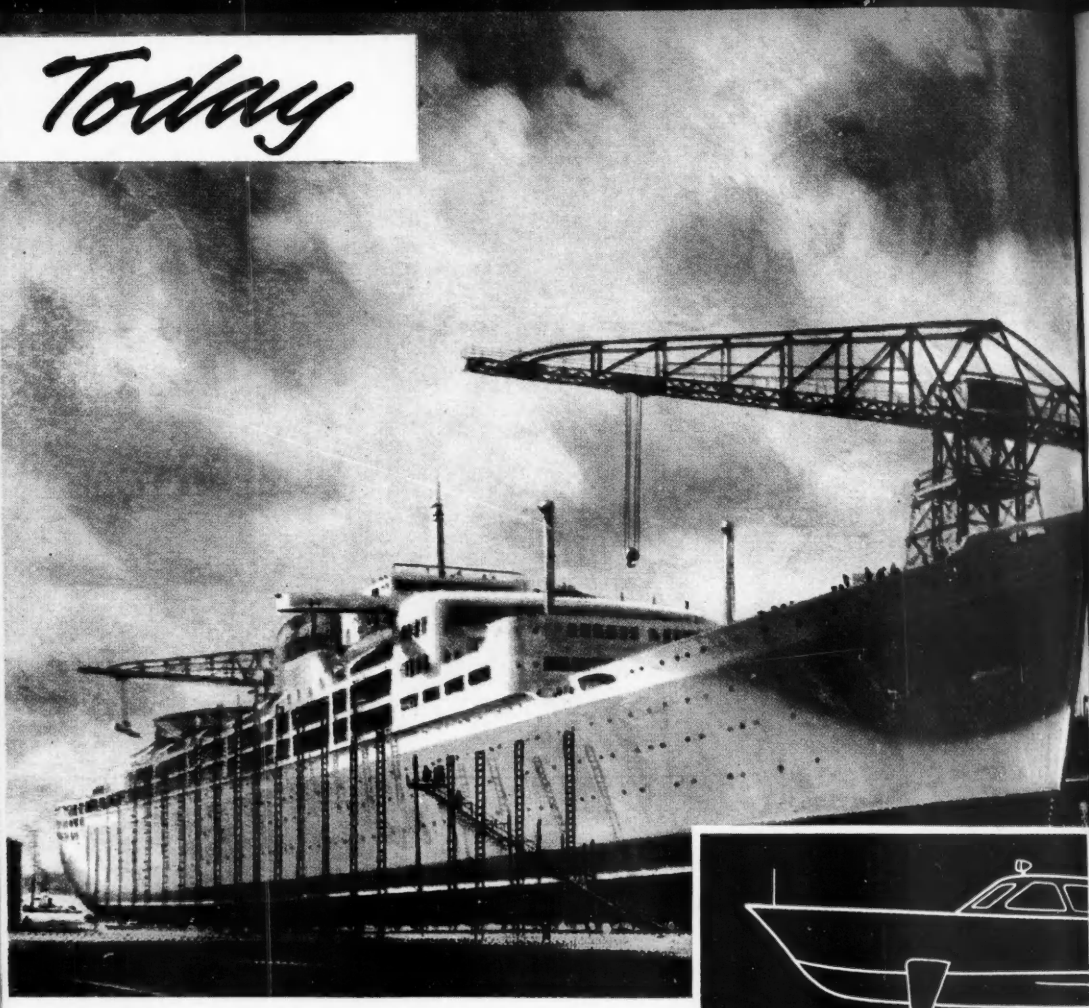
London Office : Central House, Upper Woburn Place, W.C.1. (EUSton 4086)

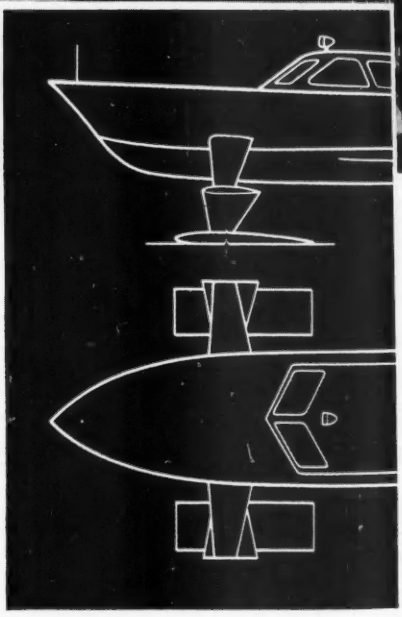
Glasgow Office : 93 Hope Street, C.2. (Central 8342/5)



H. JOHNSON FOSTER LTD. STEELMAKERS & FOUNDERS

Today





Tomorrow

Today gas is *the* fuel in forging, annealing, rivet heating and other basic heat processes in shipbuilding and heavy engineering; gas also has specialised applications such as drying before shot blasting. Industrial Gas research and consumer service ensure that tomorrow gas will be Britain's most economic fuel . . . **AND TODAY**— every industry and 12 million homes use **GAS.**

8986

ISSUED BY THE GAS COUNCIL

A22/3